EDITION B

The Journal of the INSTITUTION OF PRODUCTION ENGINEERS

Vol. XXI No. 4

APRIL, 1942

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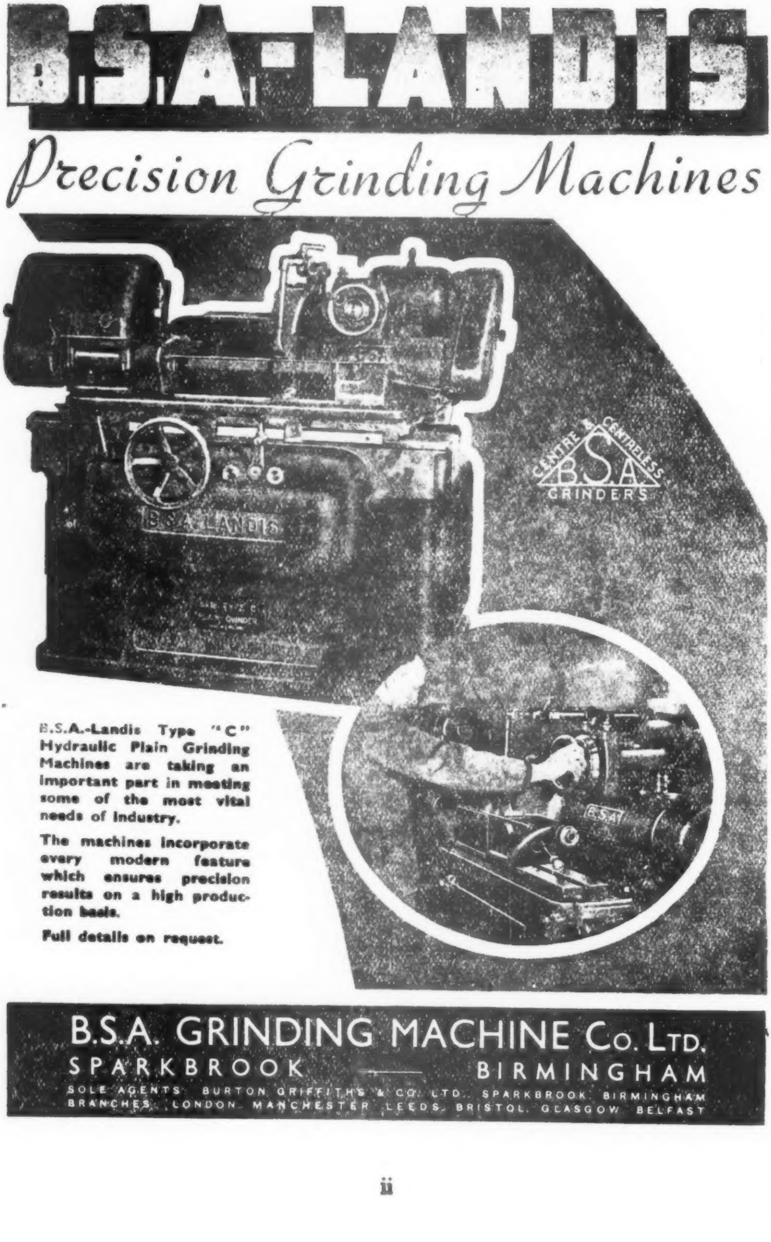
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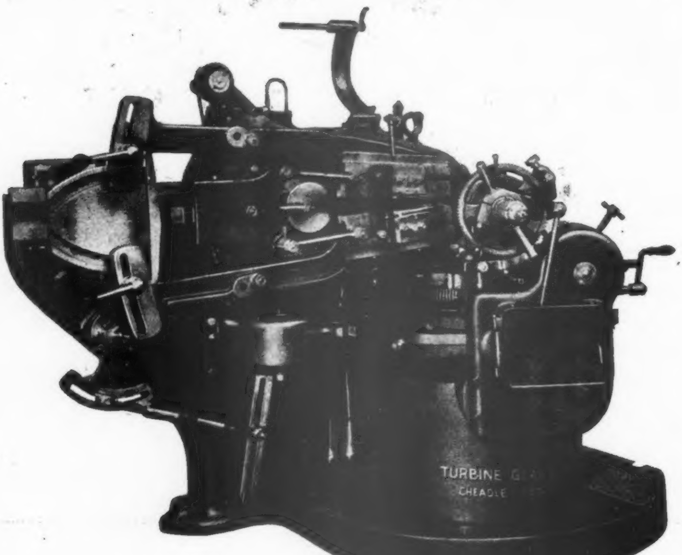

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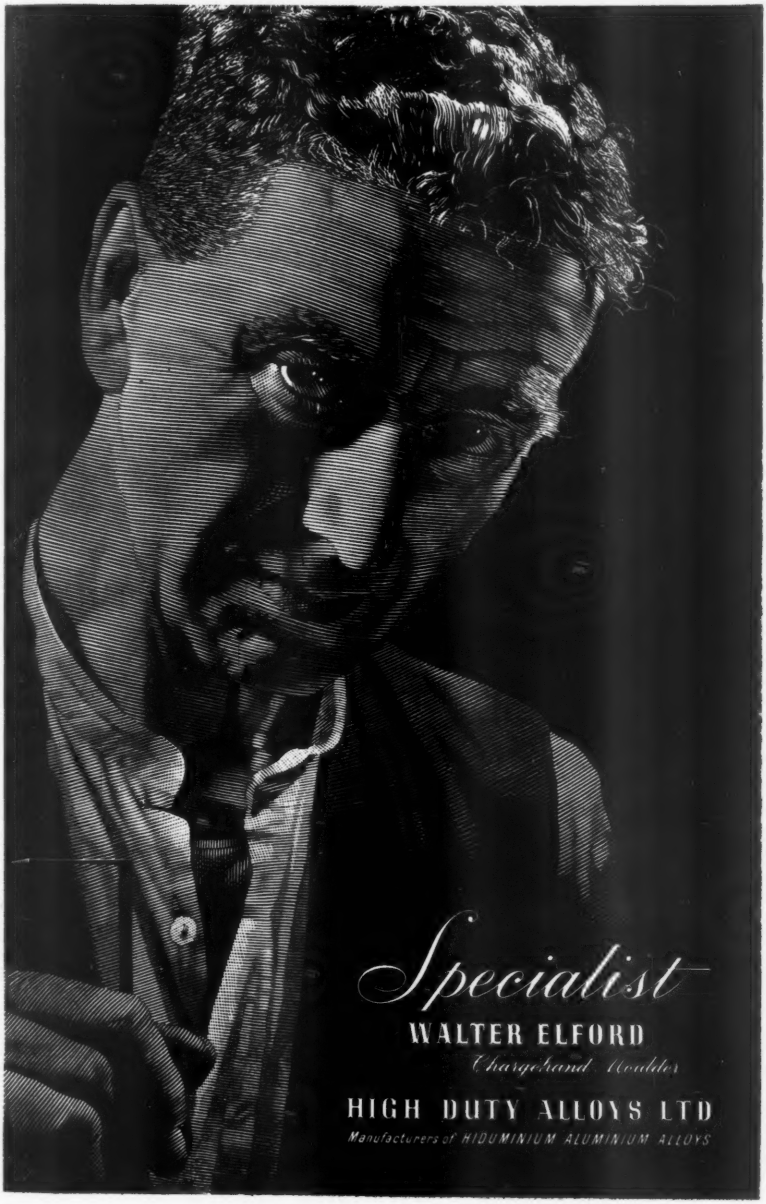
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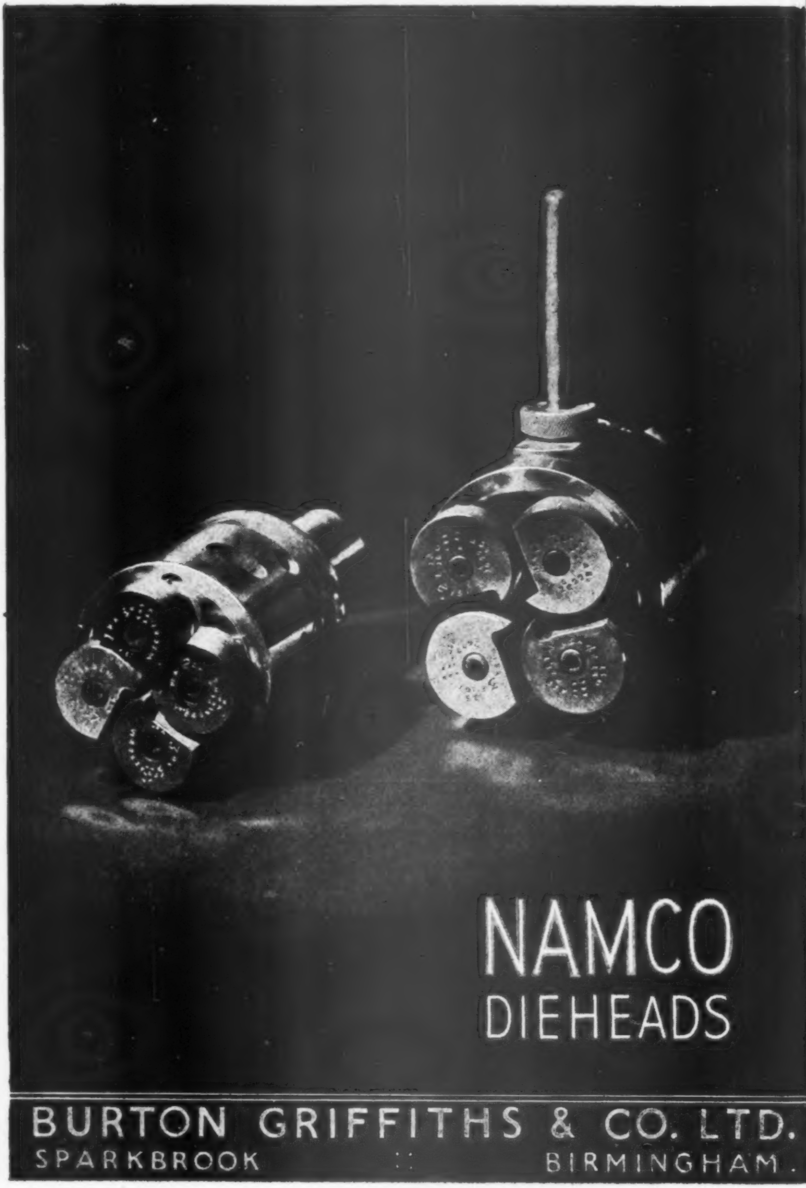
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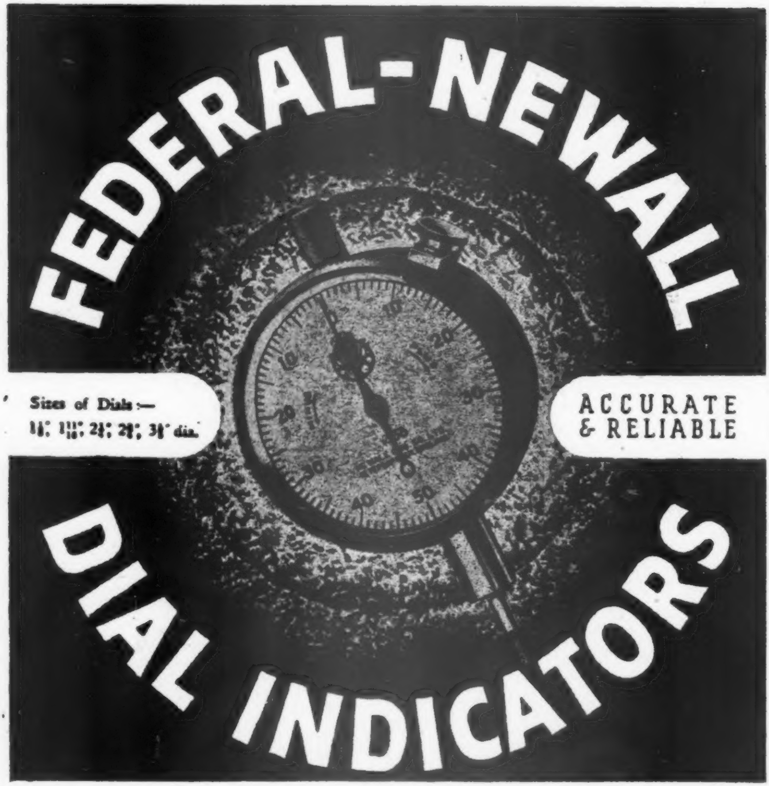

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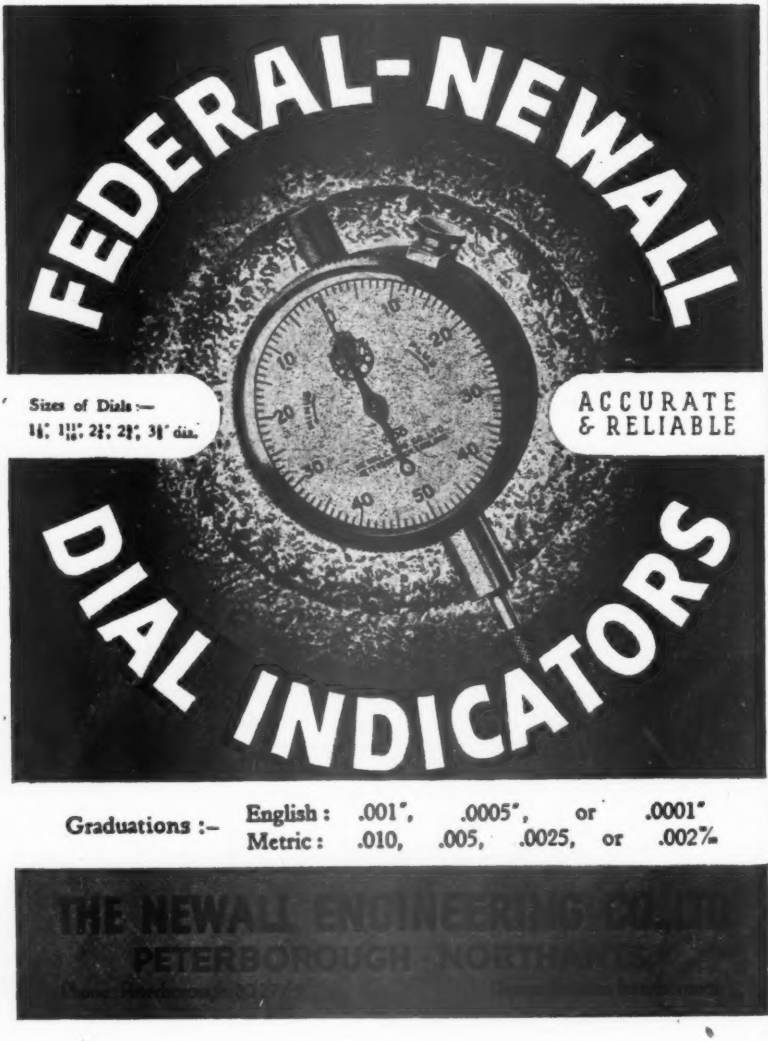
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INSTITUTION NOTES

April, 1942

Fixtures.

May 1—London Section. Lecture by Dr. Schlesinger on the Surface Finish Report of the Research Department, at the Institution of Mechanical Engineers, 6-30 p.m.

May 2—Leicester and District Section. A works visit has been arranged, jointly with the Nottingham Section, by permission of Mr. Kendall, M.P., to the British Manufacturing and Research Co. Ltd., at Grantham, at 3-30 p.m.

May 7—Leicester and District Section. Eighth annual general meeting will be held at the College of Art and Technology at 7-30 p.m.

May 9—London Graduate Section. Discussion on the use of the Ghantt chart, to be opened by Mr. A. W. Swan, 36, Portman Square, 3-30 p.m.

May 15—Yorkshire Section. Annual Section and supper, at Bradford.

May 16—Birmingham Section. A dance from 6-30 to 10-30 p.m. at the Botanical Gardens, Edgbaston.

Newly Elected Members.

As Members.—E. G. Bishop, W. Browning, J. H. Guthrie, J. A. Hind, D. S. Loudon, H. Lingwood, C. W. McKenzie, P. J. Penney. W. M. Trotter, F. Wale, P. E. Wilkins.

As Associate Members.—J. H. Arthur, W. W. Andrews, H. Brown, D. H. Brumley, H. L. W. Brown, J. E. Burnett, A. Clifford, J. F. Gibbons, H. E. Hendey, W. H. Hopkins, W. H. Kent, R. E. Leakey, J. MacGreggor, E. G. Platt, H. Pratt, R. W. Ransome, D. A. Sheret, P. H. Steer, A. H. Shepherd, J. Wallace, R. Westhorp, H. W. D. Winkworth.

As Associates.—A. H. A. Barton, C. A. Bennett, R. W. Everall, N. A. Ferguson, A. W. J. Harman, A. E. James, A. E. Hamilton Jenkins, J. M. Lawrence, H. L. V. Lobb, J. A. McKee, H. G. Parker, J. T. Simmons.

As Intermediate Associate Members.—D. G. Ansell, S. F. Broadfield, F. Clark, R. Dent, W. S. Davidson, A. Ellis, G. A. Farr, J. L. Forrest, J. M. Gray, J. E. Kelsh, E. S. Moore, W. F. Nicholas, W. R. Rowe, L. R. Targett, L. H. Tibbels.

As Graduates.—C. Bell, A. Bowery, G. L. Batty, J. M. Corbett, E. A. L. Colebourne, R. J. P. Davis, E. A. Fry, F. Grey, G. H. Hockley, C. W. Longhurst, I. S. Morton, R. C. Sinclair, J. G. Woodruff.

As Students.—D. G. Harston, H. E. Jones, J. E. Stevenson.

As Affiliated Firms.—Brooks & Doxey, Ltd., Davis & Timmins, Ltd., W. B. Dick & Co. Ltd., D. Gilson & Co. Ltd., Humber-Hillman, Ltd., Henniker Heaton Products, Ltd., MacTaggart, Scott & Co. Ltd., Platt Bros. & Co. Ltd.

Transfers.

From Associate Member to Ordinary Member.—H. Gregson, T. W. Price, H. Vernon, R. I. Whitlock.

From Intermediate Associate Member to Associate Member.—E. A. Bostock, R. W. Brown, L. R. Beesly, D. Crawcour, J. F. Hall, F. Lazenby, D. H. Mason, S. Rhodes.

From Graduate to Associate Member.—G. C. Bateman, K. J. Hulme.

From Graduate to Intermediate Associate Member.—N. R. Atkins, S. W. Hoskins, E. G. V. Law, C. Sumner, F. Tong, J. B. W. Toole.

Northern Ireland Section Inaugural Meeting.

The inaugural meeting of the new Northern Ireland Section of the Institution held on April 9, in the Great Hall of Queen's University, Belfast, was an outstanding success. Over 300 engineers were present and the speeches were followed with great interest throughout.

Mr. Alexander Brown, who presided, was elected Section President, and Mr. D. H. Alexander (Principal, Belfast College of Technology) was elected Hon. Secretary. Members of the Committee elected were Messrs. W. Browning, C. C. Bowman, E. Cuthbert, S. O. Hicks, A. F. Shillington, and W. M. Trotter.

Telegrams of greeting and good wishes were received from the President, the Chairman of Council, individual Members of Council, and from the Presidents and Committees of all the Local Sections.

Lord Sempill, Deputy President, who represented the Council, delivered an address on the work of the Institution, and other important speeches were those of the Rt. Hon. Sir Basil Brooke, Minister of Production for Northern Ireland, the Rt. Hon. H. G. H. Mulholland (Speaker of the Northern Ireland House of Commons), and Mr. D. Lindsay Keir (Vice-Chancellor of Queen's University). Short speeches were also made by Mr. Alexander (Hon. Secretary), Mr. R. Hazleton (General Secretary), and 2nd Lieut. W. Marsden (Assistant Secretary).

Leading articles dealing with the meeting and extended reports of the proceedings appeared next day in the Belfast newspapers. The new Section has certainly made an auspicious start.

A report of the proceedings will appear in *The Journal* later.

Endorsed Ordinary National Certificates.

Ordinary National Certificates in Mechanical Engineering which cover at least one approved subject in production engineering in the third year course are now being endorsed on behalf of our Institution. The first sixteen certificates under the scheme were endorsed within the past few weeks.

Courses for endorsement have now been approved at a considerable number of technical colleges and schools.

Death of Mr. P. W. Boothroyd.

We regret to announce, after a long illness, the death of Mr. P. W. Boothroyd. He joined the Institution in 1921, the year of its foundation, and was the 114th member to be admitted.

PRODUCTION CONTROL

Discussion, London Section

MR. N. V. KIPPING (Chairman of the Council) who presided: This afternoon's meeting is something of a new feature for our Institution because until now there has always been a rather strict boundary line drawn between production engineering and other production subjects. Recently your Council has given a lot of serious thought to this boundary line and has decided to admit to the Institution as Associates men who are responsible for production control. One of the curses of production is the loose and varied terms which are used both in this country and in America, and the term "production engineer" itself has over many years conveyed a picture of many different types of people, and indeed the term "production control" also has that same defect. The terms "planning production," "production control," and "production engineering" are all of them vague. We are ourselves quite clear what we mean by production control. We differentiate rather between a man who determines a method of manufacture, whom we call loosely a production engineer, and a man who is responsible for the control of the scheduling and organisational phases of production, and whom we define under the term "production control."

This afternoon we are going to have a preliminary discussion in the field of production control—a very important field and closely allied to production engineering itself. I have ventured to define or classify to some extent the various phases of organisation which fall under this heading. Your Council and the Technical and Publications Committee in particular felt this to be necessary because in the past production control men have always rather suffered from the disadvantage that as soon as their subject came up they flooded us with charts and diagrams which were, however interesting, difficult to handle at a meeting. In order to get the thing down to a basis which can be conveniently discussed, the framework which is on your agenda paper was produced, and under the three main headings of "Devising the Production Plan," "Checking the Performance," and "Stores," we have asked three gentlemen, each distinguished in his own field, to open the discussion.

31st January, 1942 (Vol XXI, No. 4, April, 1942)

Devising the Production Plan

MR. B. H. DYSON: The fundamentals of productive efficiency seem to me to be the ability to know our *productive capacity and our commitments* in quantitative terms of standard units, i.e., we must be able to measure them. I think you will all agree there is nothing that cannot be measured, and also as engineers you will agree that the more accurately one can measure the more near will the results being measured reach the standard that is required.

Many production engineers have said, and may still say, that they have often in the past had to get a quart of production output from a pint of productive equipment, but surely this is only as true as a conjuring trick in which the sleight of hand has deceived the eye, whereas productive efficiency is to get gallons of output by a continuous refilling and emptying by the efficient use of the productive pint measure. In fact, the volume which can be passed through the pint measure is almost inestimable. To achieve these results, however, can surely only be done by a *production plan of loading machine tools and equipment* with the correct volume of work per machine, per group of machines, per hour, per day of three shifts.

The amount of production that can result from running machine tools twenty-four hours per day will obviously vary according to the efficiency of the service in each individual plant, particularly in relation to the effectiveness of preventive maintenance and the size of the batch quantities.

In order to assess these we must know in definite terms our *operating efficiency* and the *economic batch quantities* that will result in attaining this operating efficiency.

How do you plan for this ? I have often felt that our measuring of efficiency started far too late in the production programme in the past, and even now it often starts and ends with using the stop watch on direct work at the bench or machine. Surely this is wrong, it should end and not begin with the direct worker if we are to assist him to produce the quality of production required in the quantity that is expected.

My experience has been that the excuse for delivery promise failures is invariably thrown on the manufacturing departments. Granted the direct productive personnel, the machine tools and equipment, or lack of them, the material or the shortage of it, or the non-continuity of orders, etc., can all provide fine excuses. On true investigation, however, I have so often found that most of the real causes are due to functions that have not been brought into consideration, or at least have not been measured before fixing the delivery date promise. I refer to such functions as estimating, designing, drawing, purchasing, process planning, time study, tool

design, tool manufacturing, tool try out, preventive maintenance, inspection planning, etc. I think you will agree that time is required for all these functions, the greater part of which must be performed before the direct manufacturing programme can commence, and unless these functions are available in the right quantity, at the right time, and prove to be of the right quality, failures that will result in missing the 'bus of delivery promises are bound to occur.

What is your capacity and load on these production service departments ? Do you know them in terms of quantitative measurement ? Do you know the capacity and commitments of your production service departments, and your production manufacturing departments BEFORE you quote for a contract, BEFORE you give a delivery promise, BEFORE you accept or refuse an order ? Remember your customer, whether a man in the street or a Government Ministry, would far rather you were careful than sorry about your delivery promises.

Granted that these problems I have mentioned are an early beginning to a production programme, I think you will agree that "well begun is half done." Do we start our production programmes half done or half baked ? Many seasoned production engineers may say that they have handled this production problem since it was a baby, but I would remind you, gentlemen, that Shakespeare said, "'Tis a wise father that knows his own child." Do we know our production baby ?

We must first of all know our problem, and as a member of the *Technical and Publications Committee* I would ask those of you who have had production control problems to help us in classifying these problems, because once they are known we shall be well on the way to devising a cure. We would also ask the assistance of all those who have had specialist experience, who can help us to formulate a recognised standard procedure that they have found effective in actual use, i.e., so that we can prepare a procedure that is advocated by men who have actually used it in order to control production and achieve results.

Checking the Performance

MR. T. G. ROSE: I should like to say how very much I appreciate the opportunity of opening this second portion of the discussion, because some time ago—six or seven years ago—I made an approach to the Council of our Institution to learn whether it was possible for something to be done in connection with the non-technical production men in industry. In my work as a consultant for sixteen years my greatest difficulty has been to find efficient and experienced men on the non-technical production side—not production engineers, but men in charge of planning and progress. Hitherto there has been no body of any kind to look after them, and

I have found it difficult to discover men with any knowledge of material control and of the non-technical side of production work. The two are complementary. It is of no use having a first-class jig designer if the non-planning side is in a complete mess and the work lies about for weeks after it has been done. The Council came to the conclusion that as we were the Institution of Production Engineers it was not possible to do anything for men who could not claim to be engineers. But now that this new grade of Associate has been decided upon it will enable us to take in those men who do have such an enormous influence on the smooth running of the place.

The subject with which I have to deal is checking the performance and the first sub-heading is the issuance of work to machine shops. We ought to appreciate that—

"There are nine and sixty ways
Of constructing tribal lays,
And every single one of them is right."

The procedure and organisation that may be most efficient for a large firm may be entirely wrong for a small one, and vice versa. Therefore we have a wide field to discuss to-day. I hope there will be no misunderstanding, someone asserting that a certain method is correct and another that he is entirely wrong and that the method will not work. Both may be right. That is my experience after many years. The methods and system adopted have to be suited to the size of the place, the product, the normal period of manufacture, and so on. What I might suggest in a production or engineering works employing, say, three hundred people, might be quite different from what I would suggest as the best method for a large firm employing two or three thousand.

Any one of the headings before us would suffice for a whole afternoon's debate, and one can only skate most superficially over these subjects. But as far as the issuance of work to the machine shop is concerned, the principle to be observed is that no order should be issued to a machine shop to do work until the works order office or the planning office has ascertained that the material is in stores and ready for issue, and that the jigs and tools, and of course the blue prints, are ready as well. Once that has been ascertained, either through the planning department or whatever the organisation may be, then there is a choice either to issue the works order with the requisition for the material to the foreman who is to do the work, leaving it to him to put that work on to the machine as soon as a convenient moment arrives, or to issue the order to the foreman to put the work on the machine, say, twenty four hours before that work has to go on in accordance with a carefully worked-out machine loading plan in which every job is

given its proper sequence. The first of these alternatives gives a fairly wide authority to the foreman, and it is understood that the planning department would not issue that order to the foreman except at a time when it would do no harm when he put it into the work. The second plan is much more prone to hitches and difficulties, because we all know that Bill Smith can do the job and Tom Jones cannot, and if Bill Smith goes off sick that morning it is no good saying that Tom Jones must do it, because he might spoil it. The foreman must have a considerable latitude of authority and, for that reason, I favour the first plan. Naturally, the operation tally will have been issued and the foreman will not change the operation without the approval of the production engineer.

As for the size of the pool of work to be made available to the shops, this should be as large as possible. Psychologically, it is always good for the shops to see plenty of work in front of them, but that work ahead should be kept entirely separate from the actual work in progress, being put either in an expanded metal store into which the shops can see or, as I have done it, put behind white lines on the floor, where the stillages or material can be seen and suggest how much work there is ahead. Everything will depend on the lay-out of the shop and the class of material handled. But I might suggest that it is always a good thing for the works to see as much work ahead as they can, though they must not be allowed to pick up anything they like and put it in hand. That has to be decided by the planning people.

The next sub-heading is the issuance of work to the assembly shops. There it is sound to put the order for the work to the assembly shops as quickly as possible. Whereas in the machine shops the order should not be allowed to go to the shop until the work material and tools are ready, the assembly order should go to the assembly shop foreman as soon as possible. That enables his progress man to keep an eye upon all that is going forward, and the assembly shop foreman to plan which job is going to be done by which man and so forth. Here I am not talking about straight repetition work but batch work, where a variety of jobs are going through the machines and through the fitting shop.

As far as the issuing of work is concerned, there the storekeeper of the finished part of the stores should spend as much time as possible getting together sets of the assemblies in stillages or sheet metal trays, or whatever is convenient for getting them ready beforehand to be issued, and he should have a blackboard or something on which he can record in a clearly visible manner what shortages he has in any particular assembly. In that he would be assisted by the progress men or the assembly foreman. The great thing is to give the storekeeper a chance to get his issues ready beforehand and to be quite sure that he has the sets complete before they are

issued out to the assembly. We know that it is frequently impossible to get a complete 100% set of parts for an assembly before they are issued. Sometimes one cannot help issuing short and chasing along the parts required to make up the set later on. To hold back forty-five out of fifty parts because one has not got the other five would not be a procedure which any practical man would consider sensible.

Again, I think that if possible the stillage for the next job should be on the floor somewhere in the assembly shop where the assembly fitters can see the next work that is coming on.

Measurement of output is the next sub-heading, but I am not quite sure exactly what it means. Naturally, the physical unit is the easiest method of measuring output—so many gear boxes, or whatever it may be. Otherwise for the assessment of improvement of effort I have taken the actual direct hours worked against the base rates recorded or the factory cost value of the goods turned out, that is, prime cost of material, labour, and factory on-cost taken per £ of direct labour or per square foot or square yard of production floor space or total floor space. It is well known that in collieries the efficiency of the men at the coal face is watched and the efficiency per total man-shift underground is compared with the total efficiency of all underground and surface workers. Here again one can take the efficiency of one's department against the direct labour in that department or the total wages paid as in accordance with the factory cost value of the work turned out. These computations are not easy, because it is not by any means all assembly departments that turn out completely finished goods. They may be working to a state of semi-completeness, the work then going to another department. Therefore, it becomes sometimes rather a complicated affair to try and value what has been done. But I have never yet found in any department, direct or indirect, that one could not measure the output of work or service in some form or other. The form in which it is done may not always be logical but it usually works.

My last sub-heading concerns signalling the job in trouble and chasing. I emphasise the fact that I am speaking of a works employing three hundred men doing general batch work. In cases of that kind I have found the most effective results to be obtained by centralising the progress men who deal with the machine shop and decentralising the progress men who are dealing with the assembly work, that is to say, the planning department will issue priority programmes to the machine shop foreman as to what priority is to be given to the work going through. This will be indicated, one or two or three, as the case may demand. Working from the planning office it will be seen that there are no hitches in getting through the work on the programmes. The men concerned can work as

messengers between the foreman with regard to any shortages or troublesome materials, breakdowns in tools, and alterations regarding drawings and so forth. They can also work hand in hand with each other, sometimes arranging for a jób to be done on another section when a machine has broken down on the first. This makes a good team in the machine shop. But when you come to the assembly shop it has been my experience that the progress men are best decentralised and each assembly or fitting shop foreman should be given a man to act as his personal assistant. Progress men get to know very exhaustively not only the work that goes on in their sections but all the parts required to do it. They can watch over the general fitter at his bench and see that he has the proper parts to go on with. They can chase up shortages, and they can go through with the foreman each week the weekly programme of output (or each month if monthly programmes are issued) so as completely to check up and keep production going.

Speaking from my own experience, that is the best method of handling progress in a works of that kind. When it comes to a very large works and to the flow of repetition production a different problem is encountered, and I am by no means prepared to say that that particular plan of centralising the machine shop and decentralising the assembly shop would be the right one.

Storekeeping

MR. C. E. A. GRIFFIN: Having been invited to open a discussion on storekeeping, a natural commencing process is to ask oneself, "What has my practical experience taught me of this subject and what have I learned from lectures, discussions, etc., which will enable me to outline broad principles of such an important production function?" In fact, on reflection, one might incline to the view that the subject being as it is, the hub of production control, has received far too small a place in the syllabus of the production engineer. For instance, we are all aware that in large concerns, considerable sums of money can be tied up and "frozen" by inefficient storekeeping, and many an organisation must have felt the effects of this "frozen hand" at some time where thousands of components are involved—moreover assembly production can sometimes be brought to a standstill by lack of ordering or faulty budgeting.

Perhaps stores departments suffer somewhat from their title, which inclines to suggest a repository for components during their passage from raw material to assembly. This rather detracts, I think, from the "fluid" atmosphere which it is desirable to create.

The fluid suggestion is, perhaps better understood by considering the policy of certain organisations who have tried to keep their components moving by routing them direct to assembly appro-

priation thus " by passing " what we might call, to continue the simile, the static store.

You may consider that this alone provides a number of interesting points for discussion and solution. For instance, this arrangement would partly assist in determining lot or batch sizes for the machine shop, which might be simple multiples of appropriation lots—does it save labour ?—and consequently accelerate components through to the assembly departments.

In short, storekeeping has its very proper and important place in production control, in company with purchasing and material control. To continue, therefore, it appears that storekeeping may be broadly divided into two, as follows : (1) Storing against a manufacturing programme. (2) Storing for specific orders, each in turn to be sub-divided and discussed in terms of raw material, semi-finished, and finished material.

It will be appreciated that any of these divisions could easily form the subject of a discussion alone, and if this address is not to assume the proportions of a lecture, can only be detailed as they fit into the general plan.

Taking now the first division—building for stock, this involves in the first instance the sales analysis, giving details of the total demand on the works over a given period—the " breaking down " of this information into terms of components, determination of maximum and minimum stocks—appropriation of set sizes for assembly—all of which, one might say being really production control, but which, in many organisations is done more conveniently in the stores proper.

Then on the physical side, the location of the stores, material requisition, purchase follow up, goods receiving notes, stock cards maintenance, stores issue orders, credit slips, counting methods, identity forms, etc., bin cards. All these forms of routine with which you are so very familiar but each having its own field of importance. For instance, I mention such a simple thing as a bin card, because within my own experience, it was decided some time ago, to abolish it. It was reasoned that stores issues and receipts *were posted* on stock record cards anyway, so why duplicate part of this work on a bin card ? So let the storekeeper concentrate on his task of physically issuing and receiving. But it was found after a trial that a very useful safety valve was lost thereby. The bin card often did show up stock discrepancies which had been brought about by clerical errors, lost papers, etc., inefficiences you will say, but nevertheless always possible. Also, in my view, it took away from the stores keeper the sense of responsibility for maintaining his stocks in accordance with records and deprived the progress department of a quick survey, there being always a certain time lag in posting issues and receipts in stores records.

When carrying stocks, also, provision will be needed to take care of components under engineer's change, redundancy, issue for re-inspection, reclaiming of scrap, not forgetting of course, our great enemy "the shortage." There are, of course, various ways of signalling a shortage, but one such scheme might be worthy of consideration, that is, the system of lights which are switched on at the end of the assembly belts and in the production manager's office when the complete sets appropriated for the assembly department are reduced to approximately forty-eight hours work. The good storekeeper, also, will work in close collaboration with the accounts side, keeping the financial aspect well in view and assisting to turn over his stock to economical advantage.

Under the second heading—storing for specific orders—the storekeeper will not have the same advantage in pre-planning, except in some instances of standard sizes of raw material, component standards, etc., and this type of storekeeping is usually identified with a limited c[illegible] of product, and often times performs the function of "shop feeding" from different centres only.

At this stage, I think we might dwell for a moment on the change which has taken place during the war years, affecting our stores systems.

Before the war most of us, perhaps had our stores systems organised under division No. 1—storing for stock—but to-day, with changes of products, set size contracts, limitations of raw materials to contract requirements and the necessity of conserving the output of machine tools for current contracts only, we find our stores system tending towards a place in division No. 2—storing for specific orders. To what extent our stores will become "shop feeders" may give us food for thought. And, arising from this, we have the oft recurring consideration—big central stores or dispersed sub-stores? and this, of course, will be largely determined by product being handled, disposition of machine and assembly shops, etc.

There are other factors, however, which have a bearing on the subject and which assist in arriving at a decision. Take for instance, personnel. What kind of a man do we select as chief storekeeper? Is he to be a statistical man who has developed on the accounts side or do you prefer a graduate from the works? You may incline to the view, gentlemen, that your ideal would be a combination of the two. Such men are not easy to get.

This makes a point for the small dispersed store, insofar as it is possible to obtain a number of men with qualifications to supervise a small store—and make them self-contained units—but it is not so easy to find a man with the experience necessary to control a big store concentration. It is the process of "breaking down" with which we are all familiar.

I have spoken of certain considerations and problems which have

occurred within my own experience, hoping thereby that others can recognise their own similar interests and thus provide subject matter for a discussion and assist in that which we are all here to do—disseminate knowledge for the further progress of the industry.

General Discussion

THE CHAIRMAN (MR. N. V. KIPPING): We have given our openers a big task in expecting them to cover so enormous a field in a few minutes. One of the most interesting points to me has been the manner in which it comes about that the system of organisation in many cases is based purely on psychological considerations. There is the question, for example, of how much work should be released in a machine shop. The comment has been made that, of course, those concerned like to see a pool of work, but they must not be allowed to get at it and attack indiscriminately because they will be likely in such a case to take first the job which may mean a lot of money or which promises a nice long run. I think, however, that the main difficulty in the whole field of production control is the difficulty of measurement. Mr. Rose mentioned that very frequently the product itself was the best unit of measurement. But the difficulty does not arise in regard to the works as a whole. The measurement there is probably fairly straightforward. It arises in the machine shops, and in the case of a largish, or even of a small works for that matter, which has a number of different shops, the question of how to measure the performance of the different shops—the press shop and so on—may be considerable.

Another great difficulty is, in the case of some general machine shops, how to measure the value of the incoming business or incoming commitments in terms of the number of press hours, milling hours, and so forth which are going to be involved. That may be easy in peace-time when we have standardised products, but it is difficult with the unfamiliar products of war-time.

Mr. Dyson drew attention to the importance of reckoning on the time factor involved in all the production control functions. In fact, even time study takes time, and he is quite right, I am sure, in drawing attention to the fact that in calculating promises and programmes there is a great tendency to overlook the time taken by the clerical operations. I suppose that this whole field is all the more difficult because of the variation in the sizes of firms. In London, at any rate, two-thirds of the engineering production firms employ less than fifty people. In fact, one-third employ less than ten people. While this fact has more interest perhaps in relation to national production for the war and so on, it has also tremendous interest in a discussion of this kind, because it draws

attention to the fact that when we are discussing production control we have to recognise that the measuring of load and the introduction of systems of control necessary in every firm, however small, are going to be immensely simplified in the firm in which everybody knows everybody else and a great deal of it can depend upon memory. When we talk about the formulation of promises and taking care to allow for clerical operations, clearly the small firm is going to be in rather a better position than the large. But this would lead us on to an interesting discussion as to what may be the right size of firms.

I should like myself to make just one or two remarks about the unfortunate individual who is known by the name of the chaser or progress engineer, according to the size of the organisation in which he works, and whether it is in America or Great Britain. The chaser is very frequently placed in an almost impossible position. It is his job to counteract to whatever extent he can the shortcomings of everybody else. In fact, I suppose the most progressive and successful concerns do, in fact, work on the principle that they expect to get the majority of their goods through without chasing. They expect that their scheduling or programme will bring about a high percentage of success, and that there will be left at the end only, say, 5% of failures. There will be some failures and their whole concern is to see that the chaser comes in on the 5% and not on the 100%. We have all known the circumstances in which nothing comes out unless it is chased, and that situation can arise in shops in which the load is accepted in excess of capacity, or in which something rather serious goes wrong, and there is no alternative but to indicate the sequence in which the work should be done by means of chasing. We all know also that the chaser with the most pleasant personality or, alternatively with the deepest pocket, is likely to be the most successful. By the " deepest pocket " I refer to his capacity to stand the foreman a glass of beer.

But it is an important point in facing the facts in relation to the chasers to settle the question of how much authority they should be given. Supposing that one is convinced that his concern has got a perfectly good system of releasing work from the shop and measuring within reasonable limits, the capacity of the shop to do the work and that the chaser in fact is dealing only with the 5% of failures. Should that chaser be given complete authority to control or even to demand a change of set-up in order that the missing items should be forthcoming, or should he depend upon the goodwill or the way in which he personally stands with the shop in order to persuade it to do the important job ? In some concerns I know, the chaser is entitled to go right back to the design engineer, to haul him along by one ear, so to speak, and to say, " Look at this, this part is holding up the whole line, and it is not coming off because of

this ridiculous limit you have put in." Or some other feature as the case may be. Indeed, he has power to cause the engineers, the designers, and other people to rush about and do something with regard to the missing parts. But in other concerns the chaser is rather a down-trodden individual, and only makes his way because of his own strong and determined personality.

I congratulate the three openers on having covered their difficult subjects extremely well, and declare the subject open for general discussion.

MR. BRAMLEY: Might I present to you one or two facts which have resulted from the attempt, as an experiment, to apply these ideas of planning in a medium organisation during the past four years. In this experiment we have found that the ability to plan depends upon determing the precise kind of work to be done before production work commences—that is, pre-determining processes and pre-determining precise times and allowances. By well tried methods of time study this can be done, though a lot of people still apparently do not do so.

Having determined the total amount of each type of work—milling work, turning work, and so on, the amount can be ascertained for each unit of product and this must be further sub-divided into the amounts for each kind of milling work and so on. These amounts for different kinds of work on each type of machine can then be divided into the machine hours available each day or each week and the lowest answer to all these division sums will give us the maximum output of our plant or, alternatively, will indicate a bottle-neck which must be overcome to enable production to be increased. I want to emphasise that this is purely a matter of simple arithmetic, once the precise amount of work to be done at each operation has been predetermined.

One of the problems which many of us come up against at present is that we are not concerned with the production of a complete unit which is assembled. We are concerned with sub-contract machining, and it is the greatest difficulty to determine precisely the amount of load to be placed on the plant and how much free loading there is in which to do extra work.

Similar results to those previously described can be obtained by copying and checking the amount of work on each machine for each weekly period and controlling the work accepted according to the number and type of machines left to be filled after the production has been put in hand. Provided the time allowances have been fixed in advance and allocated to the type of machine, this again is purely a matter of simple arithmetic.

Our experience is that an allowance of 10% on the theoretical load is quite sufficient to cover the most complicated conditions in production, and any deviations between theory and practice as

well as any additional work entailed. Having determined the maximum output or range to provide facilities for the desired output to be obtained, detailed plans must be prepared showing how this output is to be achieved. This detailed planning really constitutes the main production planning for the whole of the plant. It is divided into four main sections : (1) The main production schedule, (2) detailed schedules for each production department showing the rate of production of each piece in that department, (3) detailed material delivery schedules to show the rate of supply of raw materials from suppliers, and (4) a jig, tool, and equipment availability schedule showing precise dates when each item must be available. Such dates must have been previously reviewed in framing the mass production schedule. In a complicated production it is extremely important to bear this consideration in mind. It is very often the case that the master plan is never defined for more than four weeks, and if we have got to plan six months ahead, it is often the case that the last five months of the schedule are ordinary schedule. That is a very important difficulty to overcome, and a special technique has to be developed because it is still necessary to have a positive plan upon which production departments can work and which will not be altered except in the gravest emergency.

This technique is quite simple. It consists of preparing a p sitive planning schedule based on the master plan which calls for production slightly in advance of the master schedule during the tentative months at the latter end of the schedule. Thus we obtain a " bank " on which expected changes can be drawn without altering the instructions to the factory.

The fixing of control of batch sizes is of extreme importance in operating any planned system of production control. Batch sizes cannot be indefinitely large. If the batch sizes are too small the setting up time cost on each machine assumes too large a proportion of the total machine cost. I think I might put forward some alternatives.

Mr. C. B. Northey : I look back to the last war and to twenty one years ago when our Institution was first formed by a band of members of the production engineering profession who felt that there was a problem that had to be solved and could not be solved by the organisations then existing, particularly because the designer was not in many instances trained on the workshop production side

On looking through our agenda I wonder whether by " production control " you intend its application to the point of view of large or of small small firms. I am wondering whether or not the term " production control " is not a misnomer, because surely production control, if we come down to its pivotal point, is the production engineer. The production engineer should be the person to decide the precise plan, the planning for the shops, and what he can carry

on the load of his machines. Surely he should be in a position to say what the capacity of a particular machine is and what type of measuring stick he needs by which to measure that capacity. That is part of our training as production engineers. The problem of the measuring stick will be greater in large firms than in small ones, but it is nowhere insoluble if the organisation is such that the production engineer is being used in a proper manner.

My experience in visiting many works dealing with such a diversity of products as bomber aircraft, fighter aircraft, radio, and telephone and electrical apparatus, and many others, is that the problem I have seen confronting firms and causing them to go wrong is the fact that the production engineer generally comes in at the end of what we used to call the progress and design argument, instead of coming in at the first stage. We find that estimating departments are often under the control of the wrong people. They should be under the control of or in liaison with the production engineer. The men in charge of the departments should be trained production engineering men. But how can a man estimate how long machining is going to take unless he has that training. It appears to me on going through our agenda that the problem of the measuring stick is a production engineer's problem.

Practical capacity again is a question for the production engineer, and so is the question of how detailed loading should be attempted. Correcting for operating efficiency, economical "lot" sizes, and estimation of delivery promises are all in a sphere with which the production engineer should deal. Whether a non-technical man with no practical training could answer these problems is doubtful. With regard to checking the performance, again, the size of the pool of work is surely a matter for the production engineer. He should be able to say, "I shall be producing those parts over a certain time and therefore I want to build up that assembly." Measurement of output could be put down to progress to check up what was turned off the machines, either in value of finance or in value of time.

As to stores, I would suggest that with the exception of stores locating, this is mainly a production engineer's job. The location of stores is a controversial point, and here production engineers do not always agree with one another.

One point I notice has been omitted from the agenda, namely, time study. I find in many works that the time study engineer is generally brought in at the end and appears to be answerable to anybody except the person to whom he should be answerable, namely, the production engineer. The time study engineer should be able to go to the production engineer and point out something wrong in planning or operations. If the time study engineer is under the chief production engineer surely we should obtain a

liaison which would not be forthcoming if there was a division of responsibility.

MR. E. C. GORDON ENGLAND: Would it be possible to consider a suggestion that we have a series of discussions on this very big general subject, taking one phase of it at each meeting? I have an idea that a series running for twelve months would be of immense interest and educational assistance to most of us, and by the end of the year we should have a complete idea of the whole thing.

Mr. Dyson raised a subject which I wish he had developed a little more, namely, as to whereabouts the production engineer comes in. My view is that we want the production engineer as a co-ordinating influence in everything that contributes to the process of production. I subscribe entirely to the chairman's view that the production engineer is the coming man in this country, and the reason for it is that he is the co-ordinating influence. We are trying out in our own works the idea of putting production engineers in charge from the moment a new design is conceived. The production engineer co-ordinates the efforts of the design department, and so on right down to the end of the line. But he is a functional controller, with supreme control over everybody on the question of processes of production.

May I illustrate how that works, because it touches on Mr. Griffin's point? Somebody must think in the first instance of the influence of entering in on a new line with such things as stores. Only yesterday in discussing this question of where the production engineer touched the stores it was pointed out to me that on the consideration of a new product, which might mean handling stores in an entirely new way, there must be a co-ordinating mind at work, one who was able to see the proper taking in of the stores to the services of production. I pointed out that one could never get a storekeeper who could visualise what the production engineer would be thinking so far ahead, and that the production engineer must have a particular influence on the storekeeper. There must be a central mind at work, and that is the point I had hoped Mr. Dyson would have developed. He might give us a paper on that one subject where the production engineer starts and finishes and fits in with every other phase of activity.

MR. H. W. BOWEN: I have been interested in the remarks of the last two speakers. I think that we must all be very proud of our calling if, as they have suggested, we are coming men. It is true, however, that the production engineer may be expected to play an increasingly important part.

The present agenda will have to be sub-divided and dealt with in a series of meetings. What I do not see on the agenda, and what I think is the crux of the question—as the last two speakers will agree—is the operation sheet. The designs come through and the

production engineer deals with them immediately. He process-plans his working, material is taken off the drawing, and the amount of material for each detail is calculated. Further than that, on the operation sheet the times are put in by the rate-fixer, even if they are only temporary times. Altogether there is here, laid down on the operation sheet, a plan. Surely the bible of operation planning should be the operation sheet, and I would ask that on a future agenda the operation sheet and its working should be included as a most important part of production planning. I know that the production plan depends so much on the product, size of the firm, and so on, and I am afraid I am talking from the point of view of a large firm, my own firm having nearly 10,000 employees. But even though it is a large firm in my case, the same thing operates in a small firm, and what can operate in a large firm can, in some form or other—a less ambitious form—be successful in a small one. But again it is a question of the operation sheet, and we want to consider the operation sheet as the main issue in the planning.

MR. W. PUCKEY : Several speakers have mentioned the largeness of the present agenda, and with what they have said I thoroughly agree. One of the reasons why we put this agenda forward was because we did not know what kind of response we should get, and I want to say how gratified we are by this extraordinary attendance of two hundred members and visitors. On the other hand, there was a reason for our pessimism. In the last issue of the *Technical Bulletin* we asked all the members who were interested in production control to communicate with us, as we wanted to know to whom we might write for special information. But out of the several thousands of members of the Institution of Production Engineers only four communicated, so that you will forgive our pessimistic outlook. I can assure you on behalf of the Technical and Publications Committee, whose job it is to collate and try to put forward in some more comprehensive and perhaps more detailed form to members the material which is received, that if you can " give it " we can " take it." Nothing would please us better as the Technical and Publications Committee, or the London Section Committee, than to have a series of lectures on this particular subject.

Whenever I think of production control I am reminded of a recent examination paper, set, I believe for the Civil Service, in which the following question was posed. If it takes ten bricklayers six hours to build a brick wall 5 ft. by 5 ft., how long would it take a hundred bricklayers ? Certain people worked out the proportion and arrived at a result. But actually, of course, the result would be quite worthless, because a hundred bricklayers would never do it, they would be all the time getting in one another's way.

Mr. Dyson raised a most important point in his opening contribution. It seems to me in these days that in our practice the prepara-

tion time, if anything, transcends the production time. In many cases our preparation time on a contract takes longer than the actual production. Consequently, if we are to approach the subject of production control we have to get down to some scientific way of deciding how to estimate more accurately the preparation time on our contracts. If we do not do this we are neglecting the most important part of our over-all production plan. If any member has any ideas along those lines I would ask him to give us the benefit of them. We should be glad to hear of any measuring stick or method by which the preparation time can be more accurately assessed than it is at the present moment. The important problems confronting the manager are mainly those of the preparation time.

I want to add a word about Mr. Bramley's contribution. On behalf of the Technical and Publications Committee I should like to say that if he or others have a contribution to make which cannot conveniently be made in a meeting of this size, we shall be very glad if they will send it on to us. It will help us in our objective of getting together all the material we can on this subject of production control.

MR. TAYLOR THOMAS: The agenda is an ambitious one, and that is probably the reason why we have such a large gathering to-day. A subject of such wide scope as this is bound to attract a large number of people who are perhaps only interested in certain details of the whole scheme. I thought that I might be able to add something to the discussion regarding the solution of loading on machines. There are two problems that meet us in war-time. The first is how to estimate roughly the load when we receive an order. That can be done by the estimating department or by people who are suitably set for the purpose, so that we can get at best only an approximate estimation of what the load will be. We have tried various schemes at different times for arriving at an accurate load by taking the lay-outs and things of that order and calculating the likely load. But in any case we have to make an allowance which really more than covers the margin under which we are actually working in war conditions. Therefore, the first thing is to estimate what the load is, in an approximate sense, for acceptance of orders. But the real problem is to learn what is the real load, and this can be only done by some method of calculation of which I, at any rate, am unaware.

It may be of interest to say that we have made a fairly elaborate effort to determine what that load is. The method is to have a full time check at all times throughout the factory on the operation of the machines. We have people going around all the time recording the machines that are idle, ascertaining why they are idle, and compiling lists of the total idleness in the factory, the cause of it, and how it may be overcome. Many people would be really surprised

if they were to conduct that experiement for a short time in their own factory. When one comes to check up the machines by this means one finds that the machines on paper have a quite surprising capacity. We have known the result to come out to 30 or 40% of capacity that we never suspected to be there. I recommend that people who have not tried that out should do so if only for a short time.

Mr. Rose brought out an interesting point about the selection of suitable men for the control of production in general. I would like to add my voice to what other speakers have said on this point. I am very definitely in favour of production engineers controlling production right through. I cannot see how it is possible for a man to be selected from the shops or from the progress men, or any of the normal non-technical branches and put in a position which is technical. To make a really conclusive decision on production planning and control it is essential that the man at the head of the department should have the necessary knowledge. With regard to the progress men themselves, I do not know whether it is the experience of other people, but my own experience of progress men is that they are not as a rule of a very high standard of technical education or type. They vary, of course, but the point is surely that the progress man is there to determine the nature of any hold-up and to point it out to the people who are in a position to overcome the difficulty. The correct scope for a progress man is to discover the whereabouts of the bottle-neck or the shortage, and then to report that immediately to the production chief or to the superintendent or to some person who is of sufficient authority to see that the remedy is applied.

Mr. A. Albu: I support the suggestion for continuing these meetings and am pleased that the Institution has decided to set about the examination of this neglected subject.

In reply to Mr. Puckey as to why he did not get replies to the question he issued, the probability is that we are all very shy. This production control has been growing up during the time when most of us were in the positions we now occupy, and we have been uncertain as to how far we were being scientific or unscientific in the methods we ourselves adopted. All of us, I think, suffer under a certain sense of inferiority, especially those of us who are attached to small firms as compared with the very large firms. But if we could get together and discuss the matter we should all learn a great deal about other people's methods, and reassure ourselves. After all, as the Chairman said, the majority of firms are of very small size. Although I agree that the production engineer must be in supreme command, I think it should be possible in a large number of cases to reduce the problems of production control to office problems and problems of arithmetic. The more we can get away from

the shop and from the *ad hoc* methods and into pre-planning and control from the office, the nearer we shall be to the ideal.

With regard to the checking of the output of the machine shops (the press shop and so on), it is impossible to check the output against the required output and against the given loading unless one has very accurate rate-fixing. It can be done by taking the number of productive hours actually worked and possibly by some efficiency figure. As long as one has a sufficiently long plan period I think one will be sufficiently accurate to ensure that the required number of parts for assembly are being produced.

I was interested in the reference by one of the openers to the question of bin cards in stores. We have not had bin cards in stores for some years past. When we abolished the bin cards we took very accurate inventories. By taking perpetual inventories one can maintain an effective check, though I do not say that there may not be an occasional slip up, and probably in a large organisation the method might be dangerous.

Mr. Crocker : The last speaker pointed out that we must have really accurate estimating and rate-fixing to get the loading figures which are absolutely essential. While most firms realise this, they are up against the difficulty of finding the labour. If we had sufficient skilled production personnel who could do these clerical jobs, I think we could get through in much less time. I would like to offer a suggestion as one way of overcoming this, namely, by diluting. I think some or even a very large number of small firms would find it of great assistance to them also. In *The Journal* about three years ago we had an article which pointed out that the Germans had gone into this question of estimating in very great detail, and had actually published charts giving the times for every sort of material and cutting tool. Some big firms in this country have done the same thing to quite a large extent. Small firms have not had the time or the personnel available Is it possible that our committee would undertake the onerous task of collecting this information from the firms who have prepared some of this study and put it out as an Institution publication ? By that means the process engineer of any firm or the works manager of a small firm could run through the job, lay out the various operations, and have skilled or semi-skilled men checking the time and cost of each operation. I should like to put that forward for your consideration.

Mr. Appleby : It seems to me from what many speakers have said this afternoon that we are not exactly on common ground on this question of production control. A number of production engineers do not seem to be quite sure where the functions of the production engineer and the functions of the person concerned with production control begin and end. If this subject is to be discussed at great length and in detail, it is most important that

the vocabulary of the people speaking this language should be the same, and therefore, it is important that production control should be quite clearly defined.

I submit that production control is clerical control superimposed upon the physical movement of products through the designs, planning, production engineering, manufacturing, and stores departments.

A further point which has been raised this afternoon relates to the unit of measurement. From my experience the unit of measurement is not difficult to define, but the difficulty in arriving at a unit of measurement is a reflection of something else. I think it is quite true to say that that something else is the one thing which upsets all production plans and all production control schemes. It is the unknown factor which arises from the design stage to the completion of the product and its delivery to the stores and to the customer or Government department. This applies particularly to-day because in so many instances manufacturing organisations are asked to tackle jobs on which the design has not been finalised, and there are changes resulting not only from production information but from design information.

Another problem is that of rejects and scraps. Even given all the information available about the product at the design stage, we still have that problem to face. We have to decide how to overcome or at least how to bring about the correct disclosure of rejects and scraps in the manufacturing departments so as to prevent the hold-up on the assembly stages, when certain parts should be there and in fact are not. The problem of rejects and scrap is the problem of the physical control of movement of work through the manufacturing departments, and until that problem is seriously tackled, with its effect on loading, replacement of material, and correct utilisation of material for the achievement of a programme on a given date, we shall not get very far with production control.

MR. BROAD : I think the third item on the agenda should take the first place, namely, " Stores, " if there are to be a series of discussions. The method of checking is of first importance in getting production. Double checking on stores is also, I think, a very interesting procedure. We ourselves use the Gantt Chart method of recording both for store records and in actual planning operations.

MR. HATFIELD : In spite of what we hear from time to time about Government departments, I cannot help feeling from one experience I had in one of the ordnance factories that we went a long way towards solving the problem. The management was divided up into operations works manager, assistant works manager of production (which was my own particular function), assistant works manager of maintenance, who was responsible for plant, and administrative operations. Stores were again sub-divided. Planning was reduced

to quite a fine art by these means. I grant that in this case the production was continuous and the quantities were large. Full instructions were issued with the orders. The progress work was done by progress men who reported to the assistant production engineer. Output charts were placed on the wall in the manager's office and checked daily, and the programme was corrected by the works manager. The functions of the principal officers were laid down in writing. Complete schedules were kept of everything, and a complete record was made of machine working, practically everything that occurred being written off.

MR. G. W. CLARKE : As a member of the Technical and Publications Committee I strongly support the remarks Mr. Albu has made because I feel that this subject is so large that it requires considerably more ventilation than we can give it in the course of a short afternoon meeting. One speaker was saying just now that many of the smaller shops suffered badly from an inferiority complex in face of the larger ones. I can assure him, speaking as a member of one of the largest ones, that we have exactly the same complex, because we are continuously being told how much better the small shop can do the job. But there is one thing that I wish to mention, and which has struck me forcibly on listening to the remarks made at this meeting, that when we talk of the production plan there seems to be a very great difference of opinion as to what is meant. Some think it means having two or three chasers running about after the job, doing a little bit here and a little bit there. But it is in my mind that the view of the Institution would be that the production plan represents not only the handling of the job through the shop but the handling of the job right through the organisation.

Mr. Puckey put the point very strongly in suggesting that so frequently on a contract the preparation time may be far in excess of the actual production time. I do feel that that point should be borne in mind. What it really means is that the production plan is the joint effort of a whole lot of people. I do believe that it needs a great deal of co-ordination, but we cannot lose sight of the fact that it must be the joint effort of a whole lot of departments, many of them going outside the range of the production engineer.

MR. B. H. DYSON, in replying to the discussion, said : You have from time to time heard of some job in your organisation that is held up because the material or the tools are not available. Very often it is the absence of the tools. If we take the trouble to follow that through and find out the reason why, we could say first of all that they had not got out of the tool room. After the tools were made they had to be tried out. We can go one stage further and probably find that the tool drawing was late in getting into the tool room itself, and so the tool room had not the chance to finish in time. Taking it one stage further we should probably find that

this was due to a lack of planning in the tool drawing office or to the fact that a component drawing had not been received in time. So we could go right away back, and that is why I want to make it clear that one has to plan and measure every function. After all, it can be done. This very meeting is an example of planning. It was timed to begin at 2-30 p.m. Why ? Because we assessed that the average man went to lunch from 12-30 to 1-30, that he lived within an hour's distance of this hall, and therefore the time was fixed for 2-30 p.m. A target like that is used as a means of measurement. Each an every one of us judges and measures how far he has to go, by whatever means he is going, to time his arrival at the hour stated. That is a simple example of planning.

I quite agree that the operation sheet is an essential part of the plan. But it is too late for the production engineer to start there. I have seen a large number of planning engineers considering how they are to design a certain tool or operation lay-out on a particular component because it was an impossible production job, and that brings me to the point that the production engineer has to begin right at the early stages, even at the stage of designing for production. Following it up one stage further, several controversial remarks have been made as to whether the man who is controlling all this is to be a 100% practical engineer or is simply to be an organiser. Frankly, my experience is that if I had to make the choice of the key man to be at the head of all these functions I would far rather that he should have a keen analytical mind and an ability for organisation than purely technical ability. I do not mean that technical ability is not required, but if things are to be weighed in the balance surely it is the man who has got a keen analytical mind and has organising ability and knows where to get the information he requires who is needed in this particular respect. If he is an organiser he will have his own skilled specialists available in the right place and will know how to call on them when needed.

The Gantt Chart can be very useful. We have used it in order to time the time study, to find out how many men we needed, and how much of the programme had been time studied up to a given date, so that we could tell how much of the job had actually been covered. We can do exactly the same thing with tool design, tool making, and so on, and thus we can see, instead of merely estimating, how much of the job is done.

I could not help taking a small cutting from a daily paper which bears the slogan " It is not clever to be always late." The article was directed particularly to the worker at the bench and on the machine. But personally, I would far rather see the spotlight elevated a little and say that the precept that it " is not clever to be always late " should apply first of all in respect of the delivery

of promises, drawings, tool designs, and tools, before we say too much about the lateness of the direct operator.

Mr. T. G. Rose, also in reply, said : I do not think any of the specific points I mentioned were commented on by any other speaker, but this afternoon's discussion has shown up clearly the need for defining the whole range of this subject. Quite a number of speakers seemed to be discussing much more the administrative aspect of the production engineer's job as a whole than what I had imagined this debate was going to be about, namely, the duties or field of work that would fall to the non-production man.

I agree with Mr. Appleby that before we go on to the further discussion some more definite lines of demarcation should be drawn up. A number of the speakers were advocating that the whole process of production should be under the control of the trained production engineer. But when the trained production engineer becomes in a sense the works manager, he will still have a certain section of his work which is technical and a certain section which is non-technical, and we shall arrive back in a circle. How much of the work can be clerical and how much of it technical ? I would suggest that some more definite lines of demarcation should be drawn so that the various duties that will arise on the non-technical side can be defined.

Mr. C. E. A. Griffin : Throughout the discussion there appeared to be quite an appetite for knowledge of yardsticks for service departments. As work becomes more mental and less physical it becomes more difficult to measure. Starting with an engineer and proceeding in the direction of decreasing value in terms of mental effort, when you get down to machine hours you are at the apex of achievement. But if we know that a certain product has to be produced on a certain date, by first of all breaking down the sequence of operations and working back you will find whether or not you have enough time in the departments to complete the job. So a time table for new products can be evolved, setting up every constituent of the total process—engineer's component drawings, tool drawings, tool design, and so on, in their proper sequence. Having determined that there was a reasonable target to produce the job at the time, each particular section was set a date at which it was to be finished. Although only rough and ready, that was a target, and a rough target is better than nothing at all. In addition the date of actual completion was recorded and the information collated over a period of time and the degree of error reduced until the time taken for production of a given number of components and with a given number of tools was ascertained. That is still working and I think I am right in saying that the mental effort side of it is important because all sorts of things are wrapped up in it.

I was pleased to see that the humble bin card did receive some

comment. There is one aspect of the bin card which I have particularly noticed, and that is that it does give a very quick showing of the state of that particular component. For instance, there is always a certain time lag before records find their way back on to the accountant's figures, or whatever system you may have of recording your stock. When the bin card was done away with it took away from the progress men a very quick method of discovering their difficulties.

Finally, there was some amusing references to the indication of shortages, etc., by means of differently coloured lights. It is not, of course, suggested that that sort of scheme is suitable for a small works, but as there is such a demand for yardsticks, well, here is one. To a certain extent these lights do measure the efficiency of any particular progress man's job. If we see that a particular man is always in trouble that makes us inquire whether he has difficulties he cannot overcome or is up to his job. I was pleased to hear the reference to stores being such an important function. I believe it to be so. To take a simple illustration, how often when in difficulty do we say, "What of the stores stock?" and all our subsequent planning is based on what is our stock position.

MR. BLACKSHAW (President, London Section): It gives me much pleasure to propose a vote of thanks to the openers. We have been more than encouraged. A question which comes home to us is whether we are concerned with achieving the ideal or with—what invariably it comes round to—making the job pay? I remember when I used to think that all this that we have been discussing was a matter of simple arithmetic. I do not think so to-day. But first of all we have to come down to some form of common ground, because we shall never achieve a common yardstick which will apply to all types and forms of products.

The vote of thanks to the openers of the discussion was carried by acclamation and the proceedings terminated.

Communicated.

MR. H. MCFARLAND DAVIS: I write to express my thanks for the opportunity to attend your London Section discussion meeting last Saturday afternoon, and to congratulate you on the outstanding success of that meeting. The decision which was taken to discuss the agenda in a series of meetings which were not to be restricted in number, but were to continue until the subject had been fully examined, was I believe wise, and one which will prove very helpful to your members.

If I may, I should like to suggest for your consideration two additions to the agenda for discussion: (1) That it would be useful at the outset to draw up an organisation chart showing the position

of the production engineer in relation to all production and other departments, and to all the other executives in an average works employing, say, 300 persons all told, including the clerical side. (2) That the very important subject of potential stock be given a separate heading for discussion. This matter seldom receives the attention it deserves, seeing that reliable records of this kind enable the production engineer to know at any time not only the actual stock position, but also the forward stock position for a reasonable period, to see how the latter is arrived at, and to judge whether in, say, two months' time a new job can be put in hand in the works without placing any further outside purchasing orders for either raw material or finished parts.

Probably this would come most appropriately in section I of the agenda, as it is not a question of storekeeping. It is often dealt with by the planning section; sometimes the progress people handle it; and I have known it dealt with by the stock record staff under the cost office manager; or the works office may take charge of it.

I note that there is no specific sub-section of the agenda for the work of the methods department as such, or for that of the estimator, or for that of the jig and tool department.

THE FUNCTIONS OF PLANNING AND PROGRESS IN PRODUCTION CONTROL

Paper presented to the Institution, London Graduate Section, by L. E. Moore (Graduate)

IN examining the relationship of planning and progress in production control I feel it would be very helpful if we were first to seek an analogy in some everyday thing with which we are all familiar. Surely, all of us have at some time or another sat in an express train, travelling swiftly and smoothly to our destination, while other trains have hurtled past us, or we have rushed through busy stations and clattered over innumerable junctions and crossings, vaguely aware of the activity going on all round us, but with never a doubt that we would eventually arrive safely at the end of our journey. Most of us have taken all this for granted and probably have never given a thought to the organisation behind it.

What is the key to this efficiency? It can be summed up in the word "control"—perfect control. Never for a moment is any section of that vast organisation, over which the country's trade flows steadily month after month and year after year, out of control. How is this achieved? By perfect co-ordination of *method* and *administration*. By perfect planning first, and then perfect execution of the plan.

Production control fulfills the same function in the manufacturing industry. It provides the *method* for manufacturing the product which we term planning, and the *administration* to ensure that the method is fully carried out, which we term progress. And this afternoon we are going to consider some aspects of these two departments—planning and progress.

To provide a datum upon which to base our discussion, I would like to take an imaginary firm of between 1,500 and 2,000 productive employees, as I feel this gives us more scope for consideration of the subject. We will assume the firm in question to be engaged on the manufacture of a wide variety of aircraft components—such as mainplanes, controls, ribs, and fuselages, which I think will cover a sufficient range for our purpose. Some of these assemblies will comprise only a hundred or so detail parts, others will include two thousand odd detail parts and several hundred sub-assemblies. The types of operations involved in the detail production, besides all normal machine shop operations, and a certain amount of wood

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work, will include drilling, routing, trimming, bending and forming, nibbling, filing, piercing and blanking, flanging, welding, etc.

This is the background against which I shall outline my remarks, and if we divide the two departments into the following main activities, and briefly consider each in turn, I think we shall be able to get a very clear idea of their respective functions in the organisation.

PLANNING—comprising: (1) Estimating, (2) planning and processing, (3) tooling, (4) rate-fixing and time study.

PROGRESS—comprising: (1) Lay-out and programme, (2) shop orders, (3) shop loading, (4) distribution, (5) records.

We will now assume that the firm have been asked to quote for a customer's order. Drawings have been supplied, and these are taken in hand in the first place by the estimators, and we will now examine their activities.

Estimating.

The estimators will take the drawings and estimate the cost of the details first. Using a standard form of estimate sheet, they will show the cost of material, the cost of labour, detailing each operation, and the cost of tools. To the labour cost will be added a percentage for overheads, and this total will then be added to cost of tools and material. To this will be added a percentage for profit, and this will then give the total estimated cost of the full quantity of the article to be made on the order. This cost, divided by the full quantity, will then give the unit cost, which it is necessary for the estimator to know when he comes to his next stage, the pricing of the sub-assemblies.

This he tackles in exactly the same way, only material will now include mainly the unit costs of the finished parts included in the assembly, plus the cost of such standard items as nuts, bolts, washers, rivets, etc.

Finally, he tackles the main assembly, embracing the unit cost of all sub-assemblies and any details not so far absorbed in sub-assemblies together with further standard parts. At this stage, however, he will probably have to quote separately for his main assembly jigs, as they usually represent a large item of expenditure running possibly into thousands of pounds, and may eventually remain the property of the customer.

Having got out the prices, the progress department will be asked to quote best possible delivery dates in accordance with customer's requirements, which will be discussed at a later stage, and then the quotation will be submitted.

Assuming now that the order has been obtained, the planning can go right ahead.

Planning and Processing.

Most probably the men who gave the estimates will be the senior planners, and they will now take their estimates and the drawings, and proceed to work them into the detailed form necessary for issuing by progress as orders on the shops. They will now be able to give more careful consideration to each item, to review the possibilities of even greater savings on their estimates, which will represent increased profits for the firm. They must now decide which parts will require special equipment or operations, which the firm cannot at present perform, in which case the equipment must either be purchased if this course is felt to agree with future policy, or the parts must be sub-contracted to an outside firm capable of doing the work. This must be handled very carefully, because the cost of " bought out " parts may adversely affect the original estimate.

The material to be used must be thoroughly analysed. It will be found that some parts cannot be cut economically out of a sheet of material without nesting them together. The planning should then state the size of the sheet to be used and the number of parts to be cut out of it. This will then be used by the stores as a guide when issuing the material. The advisability of using special drawn sections must be investigated, as the saving in labour costs on a number of operations over the whole order will probably more than justify the cost of a simple draw die. There will also be the saving in tool costs through the operations cut out by using a formed section.

Next the tooling must be taken care of. In this connection, as labour is generally the biggest item in the cost of most detail parts, the cheapest labour which can possibly perform the operations required, without excessive scrap, will have been estimated for, and a little more elaboration in the tooling may make it possible to use a still cheaper labour, thereby effecting a larger saving. It may be found possible, after a little thought, to modify existing tools, or to use existing tools as they are by modifying the manufacturing processes.

In order to make the most efficient use of available labour, the manufacturing operations of each detail must be broken down and analysed, so that a skilled operator is not left to perform part of an operation which could be done equally well by a semi-skilled operator by breaking the one operation down into two.

In the course of the detail process planning a schedule will have to be prepared, to show the total hours of work under each specific operation required by the order, as it may be that existing plant will have to be increased simply to provide more capacity.

With the detail planning completed, the planner must now decide

the order of assembly and prepare his assembly schedules. He must decide what parts fall naturally into the class of small sub-assemblies requiring no special jigs. If the final assembly is a large one, requiring the bulk of the operations to be performed in a jig, he must work out what sub-assembly operations he will require to give the correct number of man-hours work in the jig. As an example, it may be that the final assembly has to be produced at the rate of one per week, over a fifty-hour week, and that the total assembly time required is 150 man-hours. The planner is satisfied from a careful examination of the drawings and from experience with similar jobs, that this can be done with three operators working full time on the job. It may quite possibly be found, however, that due to some special aspect of the assembly, three operators cannot work full time on it without obstructing each other. That being so, it will be necessary to introduce a sub-assembly stage somewhere, to absorb some of the 150 hours required in the final assembly jig.

When preparing the assembly schedules attention should be given to keeping work flowing steadily towards final assembly with the least amount of movement in and out of stores. Generally only details and small sub-assemblies should go into finished parts stores. After they are drawn out, the final assembly shop should be so laid down that the main jigs are supplied by feeder lines, producing the main sub-assembly stages at a rate equal to the output of the jigs. This reduces handling costs.

Tooling.

When planning the tools required for the detail production, it is the policy in some firms to pass a drawing of the part to the tool room foreman, stating that a "Drill and file jig" or a "Welding fixture," etc., is required, and then to leave the matter in the hands of the tool room. I don't doubt that in certain firms whose methods and production are fairly standardised this may be sufficient, but in general it is a dangerous policy. I have seen many cases of tools which were perfectly satisfactory as tools, but were most impractical in operation in the shops, due to the design of a clamp or a stiffener, or something else interfering with a production operation. Or a welding fixture has too much metal in a certain place, making it extremely difficult for the welder not to burn an adjacent part while he is heating up the surplus metal.

To prevent this sort of thing it is essential for the planner to give the tool room full particulars of the operations to be performed, and their sequence, and for the design of the proposed tool to be O.K'd. by him before manufacture.

As tools are designed in general to enable the cheapest and therefore most unskilled labour to be used, it is essential to make

them as foolproof as possible. Therefore, when very similar parts are to be made off the same tool, some sort of stop should be incorporated to prevent wrong loading.

A very elementary point, but one which is often overlooked, is the mating of detail tools with assembly jigs. It is not sufficient to produce a part off the detail tools which is satisfactory to drawing, and then to classify the detail tools as O.K. and forget about them. It is a wiser policy to classify all tools as O.K. only after the last details have gone together satisfactorily in the final assembly without a lot of extra fitting and adjusting in the main jigs. Most production engineers know only too well the difference between the job as drawn and the job as manufactured.

If the planner is considering the use of a standard tool, he should bear in mind that such a tool may be overloaded, in which case it will require duplicating.

Rate-fixing and Time Study.

When the planner has finished his process planning, the job is passed to the rate-fixers, who are responsible for putting the operational times on it. This time will be made up of a setting time, allowed for loading into jigs, or setting up a machine, and the unit or basis time which must be multiplied by the number off to obtain the total time allowed for the full quantity on the order. They will also state the minimum size of any batch under which it is not economical to manufacture, due to the increasing ratio of setting time to operational time. Most firms nowadays operate some form of bonus system, and the times are usually set by the rate-fixer, so that an average operator can make time and a quarter, a good operator time and a half, and an exceptional operator double time. If this basis is adhered to, it will provide the right spirit of incentive throughout the works, and output will be on a rising scale. Rates set too loosely, however, have an opposite effect, because it is the reaction of the operator to " go slow " for fear of making too much time and having his rate adjusted. This is a heart-breaking spirit to get into a factory, and can only be prevented by demonstrating to the operators that whatever the rate, they are free to make what time they can without fear of a cut. From the firm's point of view, the remedy is to investigate their methods of rate-fixing, and pay more attention to accurate time study.

Everyone nowadays is sufficiently familiar with the broad principles of time study to make it unnecessary for me to go into it in detail. Suffice it to say that it brings a far closer analytical observation to bear on the actual *way* in which an operator is performing an operation than the old methods of rate-fixing, and therefore tends to reveal inefficiencies, which would otherwise have gone by

unobserved. It also brings to light very clearly " idle motion " and shows the amount that this can add up to over a whole operation, which is sometimes very startling.

That I think is sufficient to give a clear idea of the function of planning. We will now go over to progress, and see what they are going to do with this data, which planning have passed to them in the form of planning cards and schedules.

Progress.

The first job for progress is to get a comprehensive view of the work to be done, and this is obtained by the preparation of a layout and programme for each complete unit to be manufactured, which we will first consider.

Layout and Programme.

The delivery requirements for the completed unit are known, and on an order for 500 units, for example, might well be required to reach the rate of ten units per week after three months. The shops have the capacity to produce the details, sub-assemblies, and final assemblies at this rate, as planning will already have taken care of this. It is obvious, however, that a complete 500 sets of every item cannot be placed on the shop at once, and therefore the order must be split up into a series of economic batches. Experience plays an important part here and accurate knowledge of the state of the shops. The batches must not be too small or they will be uneconomic to produce, nor must they be so large that they take too long to complete. The above order might well be produced in two preliminary batches of ten sets each to give closer control at the outset and guard against excessive scrap during initial production, and then sixteen batches of thirty sets. Detail and small sub-assembly production will start on this basis, aiming at a turnover rate of thirty sets in three weeks, which will enable them to get a sufficient lead over final assembly, to minimise the risk of hold-up due to shortages.

A layout chart will next be prepared, preferably on the Gantt principle, which will show the relationship of details to sub-assemblies and final assembly. During the first two batches it will be sufficient, and in fact advisable, to use the chart as a priority of production guide only, to show the starting and finishing of the respective batches. I advocate this, because in my experience I have found that planning and operational times are liable to undergo quite an appreciable alteration after the first practice run on the shops. However, by the time the first batch has been finished and the necessary alterations made, the chart can be prepared from batch three onwards to fulfil its complete function, by showing the operational times and revealing the long and short operation jobs. The

operational times can now be taken for each item and plussed up by about 25%, according to local conditions, to allow for handling and contingencies, and these can be drawn on the chart against a horizontal time scale graduated in man-hours.

A movable date scale can then be used to show the times at which each operation should be started and *must* be completed. The date scale will be changed, with the passage of time, for each batch. The chart gives, of course, the ideal state of affairs, and it is now up to progress to get as close to this as possible by good shop administration.

The next stage is to convert the information given by the layout chart into orders on the shop, which we will now briefly consider.

Shop Orders.

As soon as the material is available to place an order on the shop, the following paper work will be required : (*a*) A job label to tie to the work and go with it as it moves through the shops. (*b*) A job card for each operation, which instructs the foreman as to what is required, and gives the times for the operation. This may or may not incorporate the time card, according to the firm's cost system. If it does, it will almost certainly be required in duplicate, one copy for the time office and one copy for the operator. (*c*) A control card or slip for each operation for the use of shop progress. This may take a variety of forms in different firms, but its use is substantially the same, that is, to enable shop progress to signal the movement of work by routing this control card back to the records, when the operation is finished. (*d*) A requisition to enable the first operator to draw the raw material from stores.

The job and control cards for each operation will show the dates, as given by the layout chart, on which each operation should be started, and *must* be completed. The operation may be started earlier than the date given, but it *must* be finished by the completion date. The matter now passes into the hands of the shop progress control, who govern the shop loading.

Shop Loading.

There are many different systems of controlling shop loading, but from my own experience, I have concluded the best method to be that of a Control Board in a progress control store. Certainly, on aircraft production, with its rapidly fluctuating conditions, I know of no theoretical system of remote control from an office which can better the system of intelligent control on the spot by shop progress. If adequate shop capacity to meet the orders has been taken care of by planning, and providing the shop is correctly balanced, the progress should have no difficulty in keeping the shop loading running smoothly, while putting jobs through in the correct order

of priority. The Control Board used for this purpose combines a mechanical load chart, and can be of any size necessary to meet the requirements of the individual factory. The Board is divided horizontally into columns, approximately 1 in. wide, a column for each specific operation to be performed. At the left-hand side are listed these operations. Along the top is a movable date scale, and under this a fixed hour scale, proportional to each other, and the length of these scales governs the length of the board, and depends entirely on how many weeks ahead it is felt necessary to visibly indicate the load. A board about 5 ft. long will cover a month.

At the right-hand side are three vertical columns of pockets for the job cards, a row of three pockets against each horizontal operation column. These pockets are headed "Jobs in Operation," "Jobs Waiting," "Jobs Held," and they are used as follows:

"Jobs in Operation." In this pocket there are only the progress control cards, because the job cards are in operation in the shop.

"Jobs Waiting." In this pocket are the jobs waiting to go on the shop, in their order of priority. On the front of this pocket is a small container to take movable card numerals, which are put up to show the balance of hours' work still against that operation, over and above that shown on the chart.

"Jobs Held." In this pocket are jobs which have been out in operation, but are held up for some reason or other, and are under investigation. Here are the operator's job card, returned with the work from the shop, and the control card.

The date scale along the top is graduated to leave out Sundays and holidays, Each day this is moved one day to the left, thus recording the passage of time, and all jobs completed the previous day are removed from the chart, and the remainder moved back to the left-hand datum, while new jobs are loaded on to the right-hand end. White card inserts are used to indicate the load on the board, one for each job, and they are cut to a length proportional to the hours of work required to complete the job, using the fixed hour scale at the top of the board for this purpose. These inserts also bear the part number, job number, operation number, and date by which the job *must* be completed, all of which information is taken from the job cards. I needn't go into details of the mechanical operation of the board, because it can be worked quite simply and individual ingenuity always finds a way best suited to local conditions.

Intelligently operated, this device will simplify considerably the control of shop loading, and ensure the issuing of work in the correct order of priority. As new orders are received, the shop progress control can report immediately, with some accuracy, on the pros-

pects of completing those orders by any specified date. They will also be able to draw to the attention of planning any " out of balance " in the shop capacity, before this gets out of control.

Having now started the job in operation, it is necessary to consider briefly the means for moving it correctly, and this brings us to distribution.

Distribution.

This is the section of shop progress control responsible for the correct moving of completed work from one shop to another. Its main task is the correct routing of work and checking of quantities, to bring to light any discrepancies promptly, so that responsibility can be tied down, while the facts are clear in everyone's memory.

When a foreman has a finished operation in his section, he places the job on an OUT bench. The job card has already been passed by the shop viewer, and routed to the progress control, who clear their control card and pass the job card direct to time office to enable them to clear their duplicate clock card. Progress control thus having been notified, next send a distribution man who checks the work for quantity, and takes it back to control stores. Here he examines the route card for the particular job and finds the next operation. He then bins the job, writing the bin number on the next operation job cards and control card which are in their correct place on the Control Board. The job cards he sends out to the foreman of the next operation, and as soon as the foreman is ready to start the work (which will probably be some days later) he sends a shop labourer up to control stores with the appropriate job card, to draw the job. In this way jobs are not left lying in the shops for days before they are required, which is a great safeguard against loss and damage.

This procedure is repeated until the job is finally completed, when it is routed to finished parts stores, who book it in on a stores receipt note, one copy to shop progress control, one copy to progress office records, and one copy to cost office.

In the meantime, the completion of each operation has been recorded by the shop progress, on the appropriate batch route card, and the control card has been passed to progress office for filing. This now brings us to the question of the records it is necessary to keep.

Records.

As the planning of each part was completed the information was passed to progress office on a master progress record. On the front of this card all information is given as to material, operations, machines, tools, labour class, and times. On the back progress keep their record of the dates of starting and finishing each batch

of work, and the quantities made, together with particulars of all scrap and what steps have been taken to replace it. This is the master record retained in the progress office, and serves as a record of the orders placed on the shop. No provision is made on this card for recording the movements in the shops of the individual operations in each batch of work. For this purpose the batch route card is raised for each part number in each batch and sent to the shop progress control who maintain this record while the job is in operation. I advocate this procedure, because I am a firm believer in the progress chaser being on the spot in the shop, and that being so he will need the information given on the batch route card.

The authority for issuing the shop orders and requisitions must, however, remain in the hands of the progress office, and the master record is used for this purpose. The batch route card is a replica of the master record on its front face. On the back, however, it has provision for recording the movements of that particular batch of the part to which it refers. It is kept up to date from the control cards on the Control Board. When the part in question has reached stores, this card could to all intents and purposes be destroyed, as its work is virtually finished. However, it is sent to the office and filed for a period, in case of query, after which it is scrapped.

All these documents—the job cards, job label, requisition master progress record, and batch route cards—can be designed so that the permanent data can be reproduced on to them by mechanical duplication, and in this way it is surprising what the office can achieve in the way of output with quite a small clerical-staff of girls.

In the shops a good progress controller will be required for the control store, and according to the size of the works and the number of orders, a few girl clerks, progress chasers and distribution men will be all the staff necessary.

I have not, so far, made any direct reference to the progress control of assembly production, as I have concentrated mainly on the question of detail production, because if this is efficiently organised there will be no major difficulties on assembly.

To maintain satisfactory control of assembly the progress control finished parts storekeeper must be provided with an accurate schedule of the parts and quantities which make up each assembly, and this data must be available far enough ahead to enable the storekeeper to "pre-select" or gather together in advance the sets of parts for each assembly. In this manner any items "short" will be brought to light in plenty of time for them to be "chased."

The schedule will probably take the form of a requisition included in the assembly order which progress office pass to the stores, together with the control card previously discussed, and the necessary job cards. It will probably be found that on assembly one batch route card will suffice for as many batches of the same part

as can be recorded on it in the space available. This is due to the simplicity of operations on assembly where it is usually only necessary to record the date of issue and the date of completion of the job, all the operations being performed in one section.

The control card gives the assembly times and the date by which the job must be finished, and for visual control this information can be plotted on a Gantt Chart, drawn to show the relationship of the various assemblies vertically down the left-hand side, with a suitable time-scale horizontally along the top. The chart will be kept up to date as orders are received and completed.

To maintain efficient control of assembly it is absolutely essential to prevent unrecorded leakage of parts from stores, to replace loss or scrap on the shops. Therefore, it should only be permissible to issue additional parts to cover these contingencies upon receipt of a scrap replacement requisition, issued by the progress office. This guarantees the recording of the loss or scrap on the master progress record and its consequent replacement in due course.

That brings me to the end of my remarks. Bearing in mind that the main idea is to promote a discussion on this subject, I have outlined some aspects of production control as I have found them in my own experience, endeavouring at the same time to illustrate the principles involved. I now sincerely hope that the meeting will enlarge upon my efforts.

Discussion

MR. F. LOWE: To open a discussion on such an excellent paper as the one just given by Mr. Moore is, as you will realise, rather difficult. There are very few points which I have to raise, and would ask that everyone keeps in mind the fact that the object this afternoon is to create discussion, and therefore, members should not take too literally many of the remarks which are made, as in many cases we all say certain things with the object of getting other people's opinion on the same subject.

There are, however, one or two points arising from the paper which Mr. Moore has just given on which I would like his opinion. The first point that strikes me in his statement is that the senior planning engineer of any factory should do the estimating. I would suggest the necessity for a separate estimating department, which would, of course work in close liaison with the planning department. The second point is that I fail to see how any one can possibly estimate and give delivery dates for work to be done if it is necessary *after* receipt of the order to decide what special equipment is necessary to produce these parts. The first point about this special

equipment is that, should it be necessary to purchase machine tools, I would say that it is an impossibility to accurately give delivery dates for completion of the work without first having knowledge of the delivery of the machine tools it is necessary to purchase. It is also suggested that after the receipt of the order it would be decided on those details to be manufactured, which it would not be economical for the firm to produce, which should be sub-contracted to other firms. Here again I would suggest that the delivery might seriously effect the original delivery dates given when the estimate was made.

My third point arises on the question of tools. I would like to agree at once with Mr. Moore that the question of handling the drawing of the detail part to the tool room foreman, and telling him to make a jig, tool, or fixture is a very dangerous one, and I would like to suggest that in a firm of the size which we are considering, for example 2,000 employees, it would be absolutely necessary to have a jig and tool drawing office. Assuming that a jig and tool drawing office does exist I would like to suggest that the planning department should give a temporary operation sheet of the operations and their sequence to be performed on each detail part. It should then be left entirely to the jig and tool department to design the various equipment necessary in line with this temporary operation sheet. I would also like to ask for the experience of all members present as to whether the planning engineer should be the man to pass the design as being right. My own personal experience has been that the actual design is left entirely to the chief jig and tool designer and, should he find in the course of his design that it would be better to change the sequence of operations, he would then take these suggestions to the planning engineer. This course of events would also apply if the part being produced were a casting and location pads were necessary. In support of my views on this subject, I would like to point out that the points on any detail part which the jig and tool department might use as locations would almost certainly be in line with any other part to which they fitted on assembly. If the firm were of such size that a jig and tool design department did not exist where would the blame be attached, if the various parts did not assemble easily after production ? Among the many descriptions and explanations given by Mr. Moore to the above questions was one with regard to the fixing of the responsibility if parts were not suitable for assembly. He stated that he would make the inspection take the blame, I would entirely agree with this, but my remarks were directed to the persons being made responsible when the inspection department had previous rejected the parts—when the inspector refuses acceptance of any particular part, and it is found that it is the fault of the jigs and tools, actually who is to blame—the planning engineer,

the tool room foreman, or the man on the job ? At a later point in the discussion it was suggested by Mr. Taylor that my remarks *re* the planning engineer not being the man to O.K. the design of tools, etc., had been taken to mean that a planning engineer's job was really a clerical job, and I would therefore like to state very definitely that if a man has risen to the position of planning engineer he would, in effect, be a combination of many departments of engineering which time he must have had considerable practical experience, otherwise he would not have obtained this position. I would go so far as to suggest that to become a planning engineer cannot be learned through books.

My fourth point to raise is against the statement that the personnel responsible, providing the scheme is properly organised, would be "production controller for control stores"—a few girl clerks, progress chasers, and distribution men would be all the staff necessary. Whilst I hesitate to suggest the staff I would consider necessary, I would like to suggest that considerably more than have been mentioned would be needed.

My fifth point is with regard to the schedules being accurate. All schedule modifications should be very quickly and very accurately made, in order that wrong details should not get to the assembly lines, but the statement that the "progress control finish parts storekeeper" should pre-select or gather together parts for assembly and finding that these parts are not in stores should inform the progress department, in order that they may be chased, to me seems to be the wrong way round the job, since the job having been accurately planned it would be the progress department's responsibility to see that all the parts being manufactured would be available for the assembly lines in advance of the time they would be required. The suggestion that the schedule issued by progress would probably take the form of requisition, when passed to the stores becomes virtually an order, and since progress are responsible for the issuing of orders on the shops for parts to be manufactured it is obvious that they should not issue an order for assembly until the various detail parts are ready, also how can a progress department issue the control card stating the date the job must be finished if they have to leave it to the storekeeper to inform them of shortages ?

My last point to raise in this scheme is "What provisions are made for the replacement of the inevitable scrap which occurs in spite of most careful and detailed planning ?"

Mr. Moore, in replying, said that perhaps he had worded his reference to the need for special equipment rather unhappily. He did not mean to convey that this question would not have been considered by the estimators because quite obviously it would have to be, but in a more general way than at the planning stage. With

such a complex and generally non-standardised article as a large aircraft component it was virtually impossible to cover every contingency in the short time usually given for preparing an estimate, and such minor contingencies as had been passed over would subsequently be combed out by planning.

He agreed that in the average factory of 1,500 to 2,000 productive operatives there would almost certainly be a tool department operating. He only mentioned the question of planning O.K'ing the tool design before manufacture because he had come across the state of affairs referred to in his own experience. Should errors subsequently occur in production due to faulty tool design, which had slipped by tool try-out and inspection, then this would be the responsibility of planning.

As regards the finished parts storekeeper revealing assembly shortages. In the set up referred to this was one of his functions. He was a progress control storekeeper and had his assembly chasers based on the store, and providing progress office issued the orders and schedules in plenty of time, this system functions very satisfactorily. At the best of times progress control in the factory of an aircraft sub-contractor, such as that under review, was a healthy compromise between the ideal and the practical.

With reference to the provision for guarding against shortages on batches, due to scrap. He had himself operated two different methods. The first method was to plus up each batch by a fixed percentage, based upon experience of the likelihood of scrap. The second was to get an overlap in the batches so that at the rate of consumption and production of details a balance was maintained which left a small " float " in stores, sufficient to cover scrap contingencies. Scrap on early batches was was then plussed up on subsequent batches. Of the two methods the first had been found the most satisfactory in preventing hold-up on assembly: The second method was difficult to control, although it was necessary in the case of expensive parts.

Mr. A. Pike : I was very interested to hear the lecturer's remarks regarding factory loading, but I should very much like some further explanation as to how a correct picture is maintained. All the loading schemes that I have seen in operation have been put out owing to the fact that it is impossible to load on theoretical material, and it seems that whatever scheme is adopted it is essential to assume some date of delivery for material bought out specially for an individual order. If this comes to hand according to programme, things will work out very nicely, but it is more usually the case that there is either capacity in the shop due to non-delivery of a number of items of material and then a very heavy loading at a later date due to many items being received at once.

I was disappointed that Mr. Moore made no reference to material

control. It seems to me that the basis for the whole system of production control should be a complete part list from the drawing office. On receipt of this list someone, whether it is the planning department or a separate material control department, must go through this schedule and either order or reserve the necessary stock material for every item before the commencement of the manufacturing operations.

There is the most difficult question—the replacements of works scrap. It seems that we have a number of suggestions under this heading. Presumably, when material is rejected during inspection some form of rejection note or inspection report must be made out, and if the job is being made in one batch, this cannot be replaced in a later batch. Is it Mr. Moore's policy if the rejection occurs at an intermediate operation to hold up the correct components until the replacements have been brought up to the same operation stage as the original batch, in order to avoid double setting up on the remaining operations ?

MR. MOORE, in replying, said that drawings were received from the customer, which incorporated all the necessary material data and schedules of assembly particulars. The customer's own part numbers were invariably used, and in the set up under review, the compilation of manufacturing raw material schedules was handled by a separate department known as material control, which had not been discussed in this paper.

With regard to the occurrence of scrap on an item for which the whole contract quantity had been manufactured in one batch for economic reasons. The only satisfactory way to guard against the necessity for putting through a small quantity at a later date to replace scrap would be to plus up the batch quantity in the first place by a percentage sufficient to cover the scrap contingency.

The method of charging overheads on the basis of a percentage on direct labour is a method widely adopted in the aircraft industry.

MR. NUNN asked what influence scrap had on the charts.

MR. MOORE replied that in his experience on aircraft manufacture, attempts to visibly indicate the operational movement of work on the shops, by a fixed Gantt Chart principle were cumbersome to operate, and did not stand up well under the rapidly changing conditions occasioned by scrap and necessary modifications to programme. Under such circumstances fixed charts for this purpose became a liability, because they were constantly out of date. On the other hand charts worked on a mechanical basis, where they can be easily " reset " are an asset.

MR. HOLLAND (Chairman) asked what would be the relationship of the planner and rate-fixer or time study observer, in deciding the operational planning and tool design.

Mr. Moore replied that from the commencement of planning the closest liaison would have to exist between the planner and rate-fixer on all questions of operations and tool design.

Mr. Childs said that he had listened to the paper and subsequent discussion with great interest and had to admit that the system as laid out was sound. But he would like to know how many factories had such a system in operation. In his experience people talked a lot about production control but never seemed very eager to go any further with it.

Mr. Moore replying, said that he felt the term production control was apt to mislead a lot of people. First and foremost it stood for the intelligent and common sense application of the principles of planning, progress, and material control. There were very few engineering firms of any standing in this country which did not nowadays adopt some form of production planning. He did not feel that the same could yet be said about progressing. It seemed that the great need was to properly co-ordinate the functions of planning and progress, because neither could operate efficiently without the other. In his experience the two were rarely properly co-ordinated, but tended to operate like a cat and a dog in the same basket.

The object of production control was to co-ordinate properly and efficiently the functions of planning and progress, together with the materials department, cutting out the wasteful bickerings that so often existed, and organising the three departments and the factory, so that they all dove-tailed perfectly together.

However, although the system just discussed was designed primarily for a going concern of 1,500 odd productive operatives, its principles, in a modified form, will be found beneficial to much smaller firms. There is a great deal of wisdom in the old saying that any plan is better than no plan at all.

Another thing that has tended strongly to delay the development of production control in this country is that it has become so often merely a toy in the hands of pure theoreticians, who have never had to weld their ideas together in the actual heat of production. As a result we all probably know of the firm where the "tail is hopelessly wagging the dog" because a theoretical system has been superimposed on to a works. The management having introduced the system are loathe to admit its unsuitability and insist upon its attempted operation with the resultant inefficiency.

The seeds of efficiency lie in the heart of every organised undertaking. With some they flower naturally and without the need for external assistance. With others they don't seem to be able to get going, and this is where the intelligent introduction of a practical system of production control will work wonders.

Communicated.

MR. P. HODEE : Let us consider the shop which is getting into trouble. We must assume that there is a straight piece-work system in force and a rate-fixing and planning department in operation. There is, however, no measuring stick for load or capacity, and there is no complete load chart.

What is the load ? The answer is surely, so many hours useful work to be done in the several groups of machines in the shop. What is a machine group ? A machine group will consist of one or more machines capable of doing the same class of work. The number of different groups will, therefore, be controlled by the kind of work done. We may now obtain the load by ascertaining the quantity of each part and assembly to be made in the shop and multiplying this quantity by the piece-work price (excluding preparation allowances), for each operation and dividing the products by the operators' average earnings for the rate on which the operation has been planned. The sum of all such calculations will give the total useful work in each group which must be done in order to complete the programme. However we perform this work this is our load and it will remain constant even if we change our productive methods.

Now, what is capacity ? The answer is, surely, our capacity for accomplishing useful work. Capacity must firstly be considered on a machine group basis. This will depend upon a number of things : (*a*) The total machine availabilities in the group, (*b*) the group efficiency. The total machine availabilities will depend upon the number of machines in the group and the number of hours each machine is worked per period considered, less a percentage, say 10%, to cover cleaning and maintenance.

The group efficiency will be the ratio : $\dfrac{\text{useful work done}}{\text{total work done}}$ and will approximate to : $\dfrac{\text{production time worked}}{\text{production time worked} + \text{preparation times}}$.
Other influences will also be at work, however, e.g., time may be lost between a machine being set up and an operator starting a job. Where efficiencies are low as in jobbing and batch production small increases in idle time are important.

Group efficiencies can only be determined by complete analysis of the work as it is being done at the moment. It will be found in general that the groups with the highest activities have the lowest efficiencies.

The shop capacity for any group, therefore, is : Total machine availability × group efficiency. Total shop capacity will therefore

depend upon: (*a*) The equality between the relations—$\frac{\text{load per group}}{\text{capacity of same group,}}$ (*b*) the ability to find alternative methods of manufacture for some of the parts heavily affecting those groups where the above relation is large compared with the others. Suggested methods are changed planning and manufacture on plant in other shops wherever possible.

Loading should be complete and be the basis of the production plan. Each job should be planned from the production point of view in detail. For each part there is a date by which it must be completed. Without a complete load chart it is impossible to say what is the best quantity of that part to make at that date. In order to build up our complete load chart, we should plan the production of the parts so that the group efficiencies at least equal the average group efficiencies.

This must raise the group efficiencies in due course. Much of our trouble will have arisen by the too frequent setting up of machines to produce an uneconomical quantity of parts. Our problem cannot be solved by the continued uneconomical use of our plant. Our capacity per group, it will be remembered, is measured in available hours per group and group efficiency. Efficiency is the ratio: $\frac{\text{production time}}{\text{production time} + \text{preparation time}}$. The ratio—$\frac{\text{preparation time}}{\text{production time}}$ must, therefore, be as low as possible.

From the delivery date of the part, a manufacturing period can be estimated. On to the forward end of this period another two weeks can be added so that for two weeks the foreman can choose this job from among others of a like nature if he finds himself able to do so. In this way, a pool of work will be formed which will not appear on an emergency list. At the beginning of the manufacturing period, the chaser will present a list of parts which must be completed by a stated date. The part we are considering will appear on this list, assuming that the foreman has not been able to make it already. At the beginning of the period before the delivery date (either to store or metal finishing) which is the minimum period required to manufacture the part, chasing must be intense. Failure to meet the date must be notified to the production engineer.

The manufacturing period of this part will fall in a definite period, say, of four weeks (whether it is made before or not). The sum total of all the parts falling within the same period will give a load per group for that period.

While the scheme is being introduced, all new jobs accepted (on the existing basis), should be loaded over the whole period of manu-

facture, and all existing jobs should be tackled by periods. As the load chart develops, more information will be available for production planning, and more accurate quantities can be chosen each time until the whole existing programme is fully planned. Furthermore, during this time the shop capacity will be increasing.

In passing, a note on correcting for operators' efficiency may be made. The analysis made to determine group efficiencies will show that certain groups give a higher reward to the operator than others (which must give a lower reward) compared with the average earnings upon which the scheme is based. Group averages can then be used instead of general averages and investigations made to find to what extent batch quantities not only affect the group efficiencies, but also destroy piece-work incentives in certain groups.

Shop capacity will be known and can be increased. Machine group efficiencies will be known and planning to meet heavy or light loads will be possible. Whether a new job can be done or not will be known, and if it can, when it can be done. How best to feed the shop will be known. Plant requirements will be known long in advance. Group activities will be known in time to organise labour. The effect of changed production methods will be measurable by reflection in the group efficiencies.

MR. W. T. OCTON: At the conclusion of the paper, I was fully satisfied that all details contained therein have been practised for many years by all well organised firms. During the debate which followed, I noticed that there were present individuals who doubted the value of planning. For these people Mr. Moore's paper is most suited, for other people no.

There also existed some doubt regarding the usual procedure for producing tools. Should tools of a simple character be left to the tool room foreman's discretion without drawings? To this I definite say no.

I don't care how simple they are, every tool *must be drawn*. Reasons are too obvious to mention.

May I now say as briefly as possible what I want to see completed in the quickest possible time. It is only production engineers who can do this.

(1) Planning to be scientifically done by a body who realise the value of such.
(2) The system to be applicable to any engineering establishment since all work comes under two categories—manufacture and assembly.
(3) Planning to include all functions in any establishment. This is necessary, due to the many matters which wreck planning as we now understand it.
(4) Take necessary steps to standardise the system and educate proprietors and directors to accept as universal this system.

(5) Now for real scientific data for every operation, for the benefit of all and the country, including those who cannot see the necessity for this.

When this is attended to a planning engineer can do a job which will be appreciated. At present he lives in no man's land stopping bullets from both directions.

MR. A. E. TAYLOR: In listening to many lectures on production control, planning, and progress control, and similar lectures under different titles, I have found little to question in the actual functions outlined. These functions are fundamental and are carried out, to a greater or lesser extent, whether in the small firm controlled by one man or in the large firm with a highly organised functional type of management.

But the extent to which these functions are developed and invested in separate persons or departments, and the inter-relationship between these departments are all influenced by the size of the undertaking, the type of products produced, and the labour available, etc. It is clear that discussion in these subjects will become highly controversial unless some indication of the inter-relationship of the various functions (for the particular plant under discussion) is given beforehand, e.g. in a recent lecture it was not clearly established whether the estimating department was separate from the planning department and whether the estimates were prepared without reference to the planning department. Considering first the small shop it is obvious that production can be controlled without a great deal of paper system. In such a shop, the technical aspect would receive first consideration. The production programme would be readily visualised with little or no recourse to charts, etc., and the smallness of the shop would render direct control possible. Any adjustments to the programme would be made with very little lost time. It might here be noted that many small concerns have a standard line or product which may be made for stock during slack periods and in between times. Under these conditions, perhaps one good man might be able to control all production, in other words combine the various functions in one office.

However, when the size of the factory and the volume of production increases, one man can no longer directly control all production, and it becomes necessary to expand the control accordingly. Methods must be adopted probably involving the separate development of functions and the introduction of more paper system employing many forms, cards, and charts, etc., to give the adequate control desired.

It is evident that ranging from the very small works to the very large undertaking, there must be some kind of proportionate increase in the degree of separating the functions and development of auxiliary methods for control of production.

I have heard more than one member declare that the " One man band " is best, but I am sure that such a contention is intended to refer to a certain type of production only. Not even the most ardent upholder of the small concern would seriously suggest that all industry should be split up into " one-man " controlled affairs. How ludicrous would this be in the case of shipbuilding, and the motor car industries! The majority of us would never have been able to afford a motor car, or perhaps even a vacuum cleaner, to quote but two examples, had it not been for the development of large scale production and functional type of control.

It appears clearly indicated that economic considerations and the increasing complexity of modern industrial activities demands, in general, and especially for quantity production, properly developed types of functional management. However, there is a good case for the small concern for small scale, and special kind of production. In this way the large and small concerns might be considered complementary. Finally, any aid to production, whether by means of extra " paper-system " or a new machine, must be subjected to the acid test of adequate return on the capital invested in the proposition (in peace-time). Difficulties in assigning monetary values to indirect savings should never cause one to lose sight of this important principle.

Research Department: Production Engineering Abstracts

(Edited by the Director of Research)

NOTE.—*The addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough.*

ANNEALING, HARDENING.

Flat Surface Hardening, by J. G. Magrath. (*The Machinist, March 21, 1942, Vol. 85, No. 52, p. 1260, 9 figs.*).

The choice of three methods of flame hardening flat surfaces depends on the area of the work. (1) Spot method, (2) unit area method, (3) progressive method. The spot method is applicable to small or local areas seldom more than 4 sq. in. in size and more frequently on areas of less than 1 sq. in. Water cooled torches and water cooled multi-flame tips without quench may be used on larger areas. Welded rail ends hardened. Either the work or the torch may move in the flat progressive method. Progressive flat hardening for the inside bearing surfaces of a locomotive valve gear link. Application of flame in a circular path with the torch swung on a radius rod.

EMPLOYEES, WORKMEN, APPRENTICES.

The Foreman, by James Smith. (*Industrial Welfare, March, 1942, Vol. XXIV, No. 280, p. 35*).

Leadership is the first great quality in foremanship. Foreman in small plants. Foreman in larger concerns. A foreman is expected to maintain discipline in his department which should be a healthy and co-operative one. Arrangement of work. The pace and general spirit of a factory come from the top and the importance of setting a good example in energy, punctuality, and enthusiasm need not be stressed. A good foreman will take an interest in the well-being of the employees under his control, not in a patronising spirit but in one which evinces a readiness to help whenever possible. A foreman's job is one of the most difficult but, like all difficult jobs, one with great possibilities.

Women in War Industries, by Mary Anderson. (*Personnel, January, 1942, U.S.A., Vol. 18, No. 4, p. 195*).

Industry is devoting increasing attention to the potentialities of the women worker. To what extent is the employment of women in defence industries feasible ? What wage and hour standards should prevail for them ? And what working conditions must employers provide ? More than a year and a half ago the Women's Bureau of the United States Department of Labour started out to find the answers to these questions. Defence industries were surveyed, jobs were analysed, the war-time experience of British industry was studied. Some of the findings indicate that women can be used in numerous occupations—even in welding and riveting—for which male labour has been deemed essential.

JIGS AND FIXTURES.

The Preparation of Special Jaws for Chucking Operations, by James F. Driver. (*Machinery Lloyd, March 7, 1942, Vol. XIV, No. 5, p. 37, 7 figs.*).

Method of supporting rectangular workpiece in three-jaw chuck. Support-

ing rectangular workpiece in two-jaw chuck. Using a sample workpiece, supported on a mandrel to " mark out " the special jaws. The use of a steel ring to stress the chuck whilst special jaws are being machined to suit a second operation job. Method of supporting slender pieces. Type of chuck jaws from which the workpiece cannot work loose when back-facing.

MACHINE ELEMENTS.

Roller Bearings, by T. V. Buckwater. (*S.A.E.J., U.S.A., Vol. 50, No. 1, January, 1942, p. 20*).

This paper traces the introduction of tapered roller bearings into all phases of industry, manufacturing and transportation—particularly the automotive industry, the railroad industry, steel mills, oil industry, and machine tools. Discussing design principles, the author brings out that one of the fundamental concepts of tapered roller bearing usage is that they must be mounted in pairs and a second is that the bearings accommodate any combination of thrust and lead. For high thrust reactions, the bearing is made with a steep taper. He points out that tapered roller bearings are rated in accordance with a speed factor, life factor, and application factor, explaining how each of these factors is derived. In the remainder of the paper are discussed : Lubrication, extreme-pressure lubricants, lubricant testing, types of tapered roller bearings, contact stresses in solid and hollow rollers, starting friction on railroad axles, crankshaft and crankpin application, machine-tool applications, steel rolling mill applications, and oil-well applications.

(*Communicated by D.S.R., Ministry of Aircraft Production*).

MACHINING, MACHINE TOOLS.

Machineability, by Donald Taylor. (*Automobile Engineer, February, 1942, Vol. XXXII, No. 420, p. 51, 11 figs.*).

The main factors affecting machineability. Close co-operation between metallurgist and engineer is necessary to the achievement of optimum production conditions. In the main, ferrous metals are dealt with, but brief reference is made to other metals in normal use.

Materials, Cutting Tools, and Machineability Index, by G. Schlesinger. (*Jour. of the Inst. of Prod. Eng., February, 1942, Vol. XXI, No. 2, p. 63; 41 figs.*).

Relations between the main factors in machining metals, reciprocal influence between tools and materials. As examples the chromium-nickel alloy steels for motor car engines are treated. Comparison of machineability between German and American alloy-steels for the same use in the car engines. Selection of the best cutting angles, top rake-clearance-plan to get the maximum tool-life. Relation between speed, ship cross-sectional area, and tool-life of one hour for the various materials. Proposals to standardise the cutting angles of the tools and their shapes, and the materials with reference to their chemical constituents and physical properties. The instruments of the Research Department of Production Engineers for the research of single point turning and planing tools, and for twist drills. The definition of a machineability index : $I = \frac{Fv}{q}$. Index equal to quotient of $\frac{\text{Force}}{\text{chip area}}$. The effect of a correct chip-breaker notch to avoid dangerous chips. Relation between tool-life and coolant. Efficiency of twist drills. Forces acting at the tooth of the milling cutter. Correct and incorrect cutter drivers. Proposals to co-ordinate the cutting angles to the various materials.

Time Chart for Turning Operations, by Arnold Thompson. (*The Machinist, The Machinist Reference Book Sheet, March 15, 1942, Vol. 85, No. 51, p. 1235*).

Principles of the Honing Process. (*Machinery, March 12, 1942, Vol. 60, No. 1535, p. 175, 9 figs.*).

Chart showing grit sizes and bond grade and diagrammatic structures. Diagram showing the action of pressure, motion, and shearing force. The uniform removal of stock by honing. Chart comparing the contact areas and surface speeds of the abrading processes. Characteristics of honing-tool action : (*a*) Pressure and expansion controls built into tool, (*b*) compensations for slight misalignment, (*c*) shows abrading elements solidly supported, (*d*) the tool self-centred by the work. Correction of imperfect bores by honing. Controls used in honing equipment. Actuating controls. Type of travel path. Pathways of multiple honing sticks.

MANUFACTURING METHODS

The Manufacture of Aircraft Undercarriage Gear. (*Machinery, March 19, 1942, Vol. 60, No. 1536, p. 197, 10 figs.*).

Machining operations involved in the production of the "Airdraulic" shock absorber struts.

The Production of Aero-engine Crankshafts. (*Machinery, March 5, 1942, Vol. 60, No. 1534, p. 145, 10 figs.*).

Methods employed at a Government "shadow" factory in the manufacture of the Bristol Hercules engine.

The Production of Supercharger Impellers. (*Machinery, March 12, 1942, Vol. 60, No. 1535, p. 169, 10 figs.*).

Methods employed in the manufacture of the Bristol Hercules aero-engine.

MATERIALS, MATERIAL TESTING.

Substitute Materials and Methods for Higher Production, by E. M. Currie and R. B. Templeton. (*Industrial Power and Fuel Economist, January, 1942, Vol. XVIII, No. 196, p. 6, 4 figs.*).

Using high test cast iron for crankshafts to relieve call for steel and forgings. The main reasons for unsatisfactory performance in a crankshaft are fatigue failure, poor wear values, inability to withstand shock, etc. Foundry progress. The properties of cast iron of importance to crankshaft designers are : (1) Tensile strength, (2) fatigue strength, (3) notch sensitivity, (4) torsion strength, (5) damping capacity, (6) wear resistance. These six important properties are discussed in detail. The Meehanite cast iron crankshaft is particularly dealt with.

Automatic Magnetic Crack Detector, by E. A. W. Muller. [*E.T.Z., Vol. 62 (1941), No. 30, p. 653-658*] [*Reviewed in Z.V.D.I. (Germany), Vol. 85, No. 37-38, September 20, 1941, p. 788-789*].

The cost of magnetic crack detection in small parts is largely a question of the time taken in setting up the specimen. The author describes a machine which carries out all the manipulation automatically, provided the specimens are all cylindrical and of the same size (e.g. gudgeon pins). The pins are transferred in succession to end grips, magnetised, rotated, and sprayed with oil containing metal filings. After a definite time interval the oil spray is stopped and the current cut off. The specimen continues to rotate slowly, the inspector operating a button which automatically unclamps the specimen and allows it to drop into the "pass" or "reject" box. A new specimen is then introduced automatically and the cycle repeats. The inspector sits in comfort in front of the apparatus and can give his whole attention to the examination, without being distracted by any mechanical work.

(*Communicated by D.S.R., Ministry of Aircraft Production*).

MEASURING METHODS.

Tolerances for Spur and Helical Gears—III. (*The Machinist, The Machinist Reference Book Sheet, March 14, 1942, Vol. 85, No. 51, p. 1233, 1 fig.*).

PLASTIC MATERIAL.

Wound Plastic Bearings. [*Inter. Avia (Germany), No. 792, November 28, 1941, p. 16*].

These bearings consist of textile fabric tape, preferably linen, soaked in thermo-setting synthetic resin, before setting the resin the tape is wound on to the journal itself to a thickness of only .008 to 0.4 in. and then hardened under pressure. Owing to the small thickness of the plastics bushing so formed, contact with lubricants or even with water causes it to swell in a lesser degree than the play usually provided, so that the tolerances of aircraft engine construction can be met without prejudice to the operational safety. The new type of bearing withstands repeated alternating loads of 3,500 lb. per sqare inch, for short periods even loads exceeding 4,250 lb. per square inch, as well as operational temperatures of 120°C., whereas the wear under the operational conditions prevailing in the engine amounts to less than .2% of the shaft diameter after 200 hours of operation. Even though this value is acceptable only for the comparatively short life of aircraft engines, the new type of bearing is claimed to offer advantages as regards space requirements, protection from corrosion, and immunity to alignment.

(*Communicated by D.S.R., Ministry of Aircraft Production*).

Working-range Flow Properties of Thermoplastics, by F. E. Wiley. [*Ind. and Eng. Chem. (Ind. Ed.) (U.S.A.), Vol. 33, No. 11, November, 1941, p. 1377*].

One of the most important properties of a thermoplastic moulding compound is the temperature at which the consistency of the material renders it suitable for some forming process. Many tests have been devised to measure such temperature-consistency relations. In this paper a simple method is described which requires a minimum of apparatus and is therefore available to any laboratory. The test is capable of determining the temperature necessary for the successful forming of a plastic in many machines and processes as well as determining rheological characteristics. This method measures the co-efficient of viscose traction of a thin plastic test strip subjected to high temperatures and low stresses. The viscosity of the plastic is calculated and a viscosity-temperature chart obtained. Results can be readily correlated with those obtained on the Bakelite-Olsen flow apparatus. By this test, data on flow characteristics of thermoplastics have been obtained that are of value in establishing correct thermal conditions in certain processes. Undoubtedly there are other processes in which such data would be useful.

(*Communicated by D.S.R., Ministry of Aircraft Production*).

PSYCHOLOGICAL INVESTIGATION.

Improving Interview Techniques, by E. F. Wonderlic. [*Personnel, January 1942 (U.S.A.), Vol. 18, No. 4, p. 232*].

Despite the current vogue of employment tests, their sole value in some cases is that they indicate whom to reject. When it comes to determining whom to hire, the personnel man must depend, for the most part, on the interview. And the interview cannot fulfil its function if there is no plan behind it. From an analysis of thousands of interviews Mr. Wonderlic has discovered that every successful interviewer follows a definite pattern. In this paper he points out some of the ways in which this fact may be utilised—by personnel men to improve their own interviewing techniques and by teachers to make instruction in interviewing more effective.

RESEARCH.

Experiments on Ball and Roller Bearings under Conditions of High Speed and Small Oil Supply, by G. Getalaff. [*Yearbook of German Aeronautical Research 1938, Vol. 2, p. 110-118* (*available as translation TM No. 945*)].

The effect of bearing installation, oiling system, oil feed and oil volume, also bearing fit and clearance on the running condition of bearings are described on the basis of test runs on special machine with single-row, deep-groove, and roller bearings with 35 millimeter bearings at speeds between 16 and 21,000 r.p.m. corresponding to velocity co-efficients of from 560,000 to 735,000. (Velocity co-efficient = diameter of bearing in mm. × r.p.m.). With consideration of the requirement for minimum oil volume so essential in airplane superchargers, it was found that dependable operation could be insured with oil volumes of from five to 0.5 litres per hour (and less in many cases) when the oil was fed through a hole in the inner or outer race. The lowest figures are for roller bearings. The radial clearance is decisive for the operating temperature. Small clearances give higher temperatures. With radial clearances over 30 the operation was not always satisfactory on shafts without overhang. The reduction in clearance through the seat of the inner race must also be considered, even when the shaft is little oversize. Additional axial loads up to 120 kilograms are accompanied by temperature rise. Oil viscosity has an appreciable effect on the bearing temperature. The lowest viscosity gave the least heat, even by rising oil-inlet temperatures. The power required was approximately defined and amounted, for example, to about one horse power at 21,000 r.p.m. and 20 litres per hour oil volume. Inspection of the suitability of commercially listed bearings resulted in the preference for the light series, whereby the rising internal load on large roller body diameters is pointed out. A change in the present cage shapes so as to facilitate the entry of the oil into the bearing might make it possible to simplify the oiling system.

SMALL TOOLS.

Diamond Tools, by Paul Grodzinski. (*Aircraft Production, April, 1942, Vol. IV, No. 42, p. 318, 15 figs.*).

The rapid advance in the use of diamond tools for final machining operations. Some of the most recent types of holding fixtures. Example. Employment of diamond tools for surface milling. Micrometer boring shank. External adjusting device for small boring bars. Multiple-tool fixture for simultaneously finishing all the piston ring grooves at one setting.

Types of Drawing Dies for Forming Sheet-metal Parts. (*Machinery, March 26, 1942, Vol. 60, No. 1537, p. 240, 9 figs.*).

The line drawings show : (1) Single and double-action drawing dies, (2) combination air and toggle-action drawing die, (3) triple-action drawing die.

STANDARDISATION.

Machine Tool Electrical Standards—I and II. (*The Machinist, The Machinist Reference Book Sheet, March 28, 1942, Vol. 85, No. 53, p. 1283-85*).

N.E.M.A. industrial control standard device markings. Standard wiring diagram symbols.

SURFACE, SURFACE TREATMENT.

Surface Hardness of Metals, by Bruce Chalmers. (*The Engineer, March* 13, *1942, Vol. CLXXIII, No. 4496, p. 232, 10 figs.*).

Existing methods of measuring the hardness of metals in thin layers depend on (*a*) the scratch test, (*b*) the micro-indenter in which a very light load is applied to a pyramid indenter, (*c*) the micro-indentation test in which the indenter is fashioned to give a rhomboid shape of impression, the long diagonal

of which is measured. The new method of measurement of hardness requires two operations, namely, the application of a force and the measurement of the resulting deformation. The procedure is to drop a large number of grains of sand or particles of emery from a fixed height on to the specimen. It is therefore necessary to measure the average size of indentations, and this is carried out by measuring the reduction in the specular reflectivity of the surface. The instrument. Variation of reflectivity with weight of sand used. Analysis of the method. Relation to Vickers diamond pyramid hardness. Application to thin coatings. Effect of surface treatment on hardness. Effect of surface preparation on the surface hardness of (1) annealed copper, (2) tin, (3) nickel. Stability of the polished layer. Effect of cathodic treatment. Shape of curve for different materials. This method is of little value for measuring the bulk hardness of metals. It is, however, capable of providing data on the hardness of surfaces prepared in various ways.

TECHNICAL EDUCATION.

The Importance of Management Training for Engineering Students, by L. Urwick. (*Jour. of Inst. of Civil Engineers, March, 1942, Vol. 18, No. 5, p. 97*).

Review of the work done in management and administration from Babbage (1832), Ure (1835), Taylor (1895) to Towne, Halsey, Haldane, Burt, Fayol, Rathenau, Follett (1927). The author concludes : " Some training in management before graduation seems desirable and likely to be of great practical advantage to engineering candidates, provided always that they do not imagine that they are learning to manage. That can be learned only in practice, just as commanding armies and winning battles with them can be learned only in the school of actual fighting—never from text books on tactics and military history."

WELDING, BRAZING, SOLDERING.

A.C. Arc Welding, by Potter. (*Welding Engineer, December, 1941, p. 30*).

Reasons for the increasing prominence of A.C. arc-welding as compared with D.C. processes are discussed in this article. For practically all types of mild steel fabrication, suitable electrodes are available. When such work permits the use of welding currents of 200 amperes or more, requiring $^3/_{16}$ in. diameter electrodes, A.C. welding is said to be unquestionably more economical. Defects such as slag inclusions and porosity, due to magnetic blows may be more easily avoided with A.C. than with D.C. welding, whilst relative absence of " arc-blow " gives lower costs by making it feasible to use larger diameter electrodes and high currents, thus improving welding speeds. Also less time for training operators is claimed to be needed for A.C. systems, and low operation costs are obtained by higher electrical efficiency and less maintenance cost.

(*Communicated by Research Dept., Met.-Vick.*).

High Speed Arc Welding, by S. G. P. de Lange and E. S. Waddington. (*Sheet Metal Ind., February, 1942, Vol. 16, No. 178, p. 224*).

Steel welding. By use of electrodes with high rate of deposition savings of 25 to 45% of welding time are claimed with corresponding reductions in overhead costs. Good properties are claimed for the welds deposited.

(*Supplied by the British Non-ferrous Metals Research Assoc.*).

Welding the Stainless Steel, by H. S. Marquand. (*Welding, March, 1942, Vol. X, No. 2, p. 35, 6 figs.*).

For the purpose of this article all grades of stainless steels are classified into three groups : (1) The straight chromium martensitic hardenable steels containing less than 16% chromium, (2) the non-hardenable or ferritic straight

chromium steels containing chromium in excess of about 15% and (3) the austenitic or chromium-nickel alloys. Effect of chromium. Weldability of alloys in groups (1), (2), (3). Weld decay (intergranular corrosion). Three thousand gallon cylindrical tank, 8 ft. 3 in. in diameter and 10 ft. deep. Built from 12-gauge stainless steel sheet.

Lead Welding, by A. J. T. Eyles. (*Mechanical World, March 27, 1942, Vol. CXI, No. 2882, p. 267, 5 figs.*).

Details of technique for fabricating tanks, plant linings, duct work, and the like. Although there are several systems of leadburning or jointing available, such as oxy-acetylene, oxy-hydrogen, oxy-coalgas, air-acetylene, air hydrogen, and oxy-butane, experience shows that the oxy-acetylene system is faster than the others. The average craftsman readily acquires the skill necessary to produce good fusion welds in sheet and plate leadwork after some little tuition. Preparation and width of joints. The illustrations show. Upright welded seam, a lapped weld and butt welds, lining a large tank, welding a lead fume-duct.

Soldering Hard Metal Tips on Tool Steels, by K. Steinbecker. [*Masch. Markt., Vol. 46, 1941, No. 49, p. 15. Reviewed in Z.V.D.I (Germany), Vol. 85, No. 37, 38, September 20, 1941, p. 788*].

Hard metal tips on tool steels can be attached either by means of a welding flame, high temperature furnace, or use can be made of electric resistance heating. In the latter case the usual procedure has been to clamp the tipped tool between two copper electrodes, the current then passing through the hard metal plate and underlying copper foil (acting as solder) to the tool holder. This is liable to cause local overheating due to differences in contact and resistance and may damage the tip. The author describes a modification of the process, in which the tool steel forms one electrode and is heated by contact with a single copper electrode. The heat generated melts the solder and the hard metal tip is then pressed on the soldered surface by means of an elastic roller. The device uses alternating current and a transformer with several tappings is incorporated so that the heating current can be adjusted depending on the cross-section of the steel tool, the current connectors to the steel and copper electrode being water-cooled. For steel cross-section of 10 × 10 mm. and 20 × 20 mm. the soldering time amounts to 1.5 and three minutes respectively, the electrical rating being eight kw.

(*Communicated by D.S.R., Ministry of Aircraft Production*).

Soldering and Brazing—Their History and Development, by H. R. Brooker. [*Met. Ind. (London), January 30, 1942, Vol. 60, No. 5, p. 73*].

An account of developments from early times up to the modern special alloys.

(*Supplied by the British Non-ferrous Metals Research Assoc.*).

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